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Supply Chain Analysis of Gabilan Manufacturing Inc.

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December 2003

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SUPPLY CHAIN ANALYSIS OF GABILAN MANUFACTURING INC.

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ABSTRACT

The purpose of this MBA Project was to investigate and provide alternative supply chain management strategies to assist Gabilan Manufacturing Inc. in reducing supply chain costs. This project was conducted with the sponsorship and assistance of Gabilan Manufacturing Inc. There were two primary goals of this project. The first was to identify and document the impact of forecasting errors in an environment where customer forecasts are available to the vendor. The second was to investigate the costs associated with relocating cutting operations as well as the procurement impact of a new cutting machine. Both of these goals relate directly to the overall effort to reduce supply chain costs without a loss of service level to Gabilan's customer.

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EXECUTIVE SUMMARY

Gabilan Manufacturing, Inc. (Gabilan) designs and manufactures mufflers for motorcycles. They are the sole-source supplier of mufflers to a major motorcycle manufacturer and have been working with their customer since 1978. Throughout the past several years, foreign competitors have maintained or lowered their supply chain costs allowing them to reduce motorcycle prices. In order to compete and maintain their position at the top of the motorcycle market, Gabilan Manufacturing, Inc.'s customer has mandated scheduled price reductions from their suppliers. In reaction to this mandate, Gabilan commissioned the Naval Postgraduate School to study their operations in an attempt to determine where they may achieve efficiencies and reduce supply chain costs in order to meet their customer's requirements.

Two specific areas of Gabilan were studied: demand forecasting and the steel-tube cutting operation. The demand forecasting analysis examined the value of sharing information between Gabilan and their customer and its impact on the production schedule and suppliers. Field studies in support of the demand forecasting analysis were conducted at the main manufacturing facility in Salinas, California and the warehouse and staging facilities in Emigsville, Pennsylvania. The steel-tube cutting operation analysis examined capacity, resource allocation, and utilization of machinery. Field studies for this part of the analysis were conducted at the Salinas, CA manufacturing site, the Lincoln, Nebraska manufacturing site, as well as the perforated steel-tube supplier's manufacturing site also located in Lincoln, NE.

The demand forecasting analysis examined seven stock keeping units (SKU's) of different muffler types, comprising 85 percent of the business with Gabilan's customer. Each week, the customer provides Gabilan a 16-week forecast of their SKU requirements. Those forecasts were analyzed to determine their accuracy and the impact of forecast errors on production planning and inventory levels. The analysis showed that, on average, the 16-week forecast

and actual demand vary by a significant amount. If Gabilan produced to the forecast, they would consistently be short on production and would not be able to maintain the service level required by their customer, so in order to meet the expected higher demand they produce twice as much mufflers as needed. The incorrect forecast, however, affects more than just the number of mufflers provided to the customer. The disparity between the poor forecast information and the actual number of mufflers demanded increases the amount of stock needed in the system in the form of additional raw materials and additional finished mufflers. This variability also impacts decisions regarding human resources, capacity, and production planning. Several models were developed to assist Gabilan correct the forecast error and more accurately predict future demand.

The second part of this study focused on the steel-tube cutting operation. One of the initial reasons Gabilan commissioned this study was a perceived capacity problem with their steel-tube cutting operation. They were considering the procurement of an additional cutting machine to alleviate that problem, but wanted to know where they should locate the new machine. As the study progressed, it became apparent there might be more than just a capacity problem that warranted attention so further analyses were conducted. In addition to a base-line cost analysis of the existing cutting operation, three scenarios were developed to study the costs associated with procuring new capital and the location of the cutting operation. After showing considerable cost savings that could be achieved by the relocation of the cutting operation, two additional scenarios were developed to determine the cost savings that could be achieved through increased machine utilization. Increased utilization of existing machinery, even to a conservative target, yielded significant possible savings and in certain cases, even greater savings than through investment in new capital. Finally, in addition to the cost models developed, risk analysis was conducted in order to provide a realistic range of cost savings achievable in each

scenario which will allow Gabilan Manufacturing, Inc. to determine its potential worst case and best case scenarios for decision making purposes.

The findings of this study were presented to Gabilan Manufacturing, Inc. 26 November 2003. The executive-level briefing presented to Gabilan is included in this report as Appendix A1. The brief details and shows the results of the analysis, and provides recommendations to the organization. To protect the confidential nature of the data, they have been modified in this report. Neither the analytical approach, nor the conclusions were significantly affected by this modification.

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I. INTRODUCTION

A. Overview

Gabilan Manufacturing, Inc. is a company that makes mufflers for a large motorcycle manufacturer located in the United States and contributes to a small portion of the “after market” muffler sales for motorcycles made by the same manufacturer. Gabilan has two manufacturing sites and one storage/distribution site. The Lincoln, Nebraska manufacturing site is very specialized and only creates mufflers for one type of their customer’s motorcycles. The Salinas, California site houses the main manufacturing functions that create all other mufflers used by the customer and is also the location of the corporate headquarters. The storage and distribution center is located in Emigsville, Pennsylvania and directly supports their customer’s manufacturing plant in nearby York, Pennsylvania.

Gabilan has been manufacturing mufflers for their customer since 1978 and presently Gabilan is their customer’s sole-source supplier of mufflers for all models of their motorcycles. As the sole source provider in a high speed, high tech, just-in-time, manufacturing environment, Gabilan has a critical responsibility to its customer to make sure that the delivery of mufflers is not interrupted. Gabilan has committed to provide a 100% service level for all muffler types, even when unforeseen events cause disruptions in the supply chain, potentially causing a significant impact throughout their supply chain operations. Those organizations that provide Gabilan with the necessary raw materials required to manufacture the mufflers are also affected by the service level commitment. Because of this, Gabilan has had to develop excellent working relationships with their suppliers. When either Gabilan or one of their suppliers has a problem at any point in the supply chain, Gabilan must get involved with solving the problems and setting up systems to avoid delays.

B. The Business Problem

Gabilan's customer is committed to staying competitive in a tightly contested market for cruiser-style motorcycles. Foreign competitors have been able to maintain their costs, and in some cases, lower costs and pass them on to the consumer in the form of lower-priced motorcycles. In order to keep their position at the top of the market and compete with the foreign firms, the customer has mandated scheduled price reductions from their suppliers through 2010. Because of this push to decrease costs, the customer is using its market power to force their suppliers find ways to cut their costs or potentially lose their business. This is especially true for Gabilan, because their entire business serves only one customer – hence that customer has a monopsony similar to that enjoyed by the Department of Defense (DoD) in some of its acquisitions.

A monopsony is a market situation in which only one buyer seeks the product or service of several sellers and is also called a buyer's monopoly. As often the largest employer and generator of revenue in different areas of the United States, and in conjunction with various statutory federal acquisition regulations, the DoD often makes full use of it's monopsony status. Suppliers often have to provide all their cost and profit information for DoD to make a determination on how much to actually pay that specific supplier. Section VI of this paper further discusses monopsony as it relates to the DoD.

C. The Business Solutions

The primary concern for Gabilan's logistics planners is the length of time it takes from the time the customer submits a requisition for a muffler to the time that required muffler is received at the customer's factory. This is not only the time it takes Gabilan to manufacture an item, but includes time spent on administrative tasks, waiting on input material shipments, and the time associated with shipping the finished products to its customer. Reductions in cycle times can have added benefits to the organization that can result in further realized cost savings. Muffler cycle time is directly associated with the level of inventory that must be maintained at each manufacturing site and at the

storage/distribution site. If Gabilan can reduce the cycle time, they can also reduce the amount of inventory that must be maintained in order to protect against the variability in demand experienced during lead-time. Although inventory has a monetary value, excess inventory does nothing more than tie up valuable monetary resources that could be used more effectively in other areas of the organization. Even if the money is not needed in another part of the organization, the cost savings achieved by reducing inventory levels by reducing cycle time can be significant. By reducing cycle time or inventory, Gabilan also reduces the physical space leased or purchased to hold the inventories.

This study analyzed two areas in which Gabilan can achieve cost savings through the reduction in cycle time and other areas of the supply chain. Sections two and three analyze the area of demand forecasting while sections four and five examine the steel tube cutting operation. The demand forecasting analysis examined the impact of cycle time and variation reduction on the production schedule and suppliers. The steel-tube cutting operation analysis examined capacity, resource allocation, and utilization of machinery. To protect the confidential nature of the data, they have been modified in this report. Neither the analytical approach, nor the conclusions were significantly affected by this modification.

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II. INFORMATION SHARING

A. Overview – Literature Review

In an environment of lean inventories, businesses are more dependent on the relationships they have with their suppliers and demand that they adhere to high standards. The establishment, development, and maintenance of relationships between both buyers and supplier are crucial to achieving success within an integrated supply chain (Morgan and Hunt, 1994). One of the ways supply chains become integrated is through the sharing of information and the use of information technology.

The value of shared information and information technology has had a substantial impact in achieving an integrated supply chain. The use of sophisticated technologies such as scanners, Electronic Data Interchange (EDI), Radio Frequency Identification Tags (RFID), and the implementation of Enterprise Resource Planning (ERP) systems have enabled large amounts of data to be shared with minimal complications. The direct application of these technologies has substantially lowered the time and cost among the various levels within the supply chain while simultaneously leading to impressive improvements in supply chain performance (Cachon and Fisher, 2000). Several studies of various industries have shown considerable corporate advantages with the use these technologies and they report that the same advances can also be applied in the value of sharing demand information to improve supply chain performance.

Lee et al. (2000) report the use of shared information to improve the supplier's order quantity decisions. They show that the characteristics of the demand process and the replenishment lead-time have significant impact on the benefits of information sharing to the manufacturer. The manufacturer obtains larger reductions in terms of average inventory and average cost when the underlying demand is highly correlated over time, highly variable, or when the lead-time is long. This is highly relevant to Gabilan's situation as they can

present the results of Lee's study, along with this analysis, to their customer as further support for the importance of accuracy in the forecasts provided by the customer.

A different study conducted by, Aviv (2001), explored the benefits of sharing forecasts for the future demand. The study developed and examined two models between a supplier and a retailer. The first model was called local forecasting in which each member updated the forecasts of future demands periodically, and was able to integrate the adjusted forecasts into their replenishment process. The second model was named collaborative forecasting and in it, the supply chain members jointly maintained and updated a single forecasting process in the system, which thus became a centralized system. The study determined that the potential benefits of using a local forecast were mainly dependent on forecasting strengths and they become significantly larger as the forecasting strengths increase. However, the results determined that using a collaborative forecast provides benefit only when the diversification of forecasting capabilities matter, i.e., whether or not the trading partners can bring something unique to the table. Gabilan can also use this study based on the first model's recommendations to provide recommendations to their customer on why they should "firm up" or strengthen their forecasts.

Many industries have embarked on reengineering efforts to improve the efficiency of their supply chains. The goal of these programs is to better match supply with demand so as to reduce the costs of inventory and stock outs. One key initiative that is commonly mentioned is the information sharing between partners in the supply chain. Sharing sales information has been reviewed as a major strategy to counter the bullwhip effect. The bullwhip effect is the phenomenon of demand variation amplification along the supply chain. This phenomenon can be characterized as demand distortion, which can create problems for suppliers, such as grossly inaccurate demand forecasts, low capacity utilization, excessive inventory, and poor customer service (Lee, et al., 2000).

Raedel (1995) states that uncertainty of supply and demand can take two forms. The first is quantity uncertainty, i.e., not knowing exactly how much will be required or how much will be delivered. Causes of quantity uncertainty include defects in the material supplied, varying yield rates or material orders by batches that vary in quantity. The second form of uncertainty is timing uncertainty. The primary cause of timing uncertainty is lead-time uncertainty from suppliers or internal processes. A firm may have orders for specific quantities, but the exact timing of the requirements is subject to change. He further states that inventory that is kept to handle quantity uncertainty is called safety stock. Safety stock is set aside to achieve the desired protection or service level. One can manage uncertainty through the use of safety stock, but the only way to truly reduce uncertainty is to improve information sharing and supply chain processes. According to Raedel (1995), one of the prime reasons to maintain inventory is to deal with demand variability during lead-time. Total lead-time includes product design, materials procurement, and manufacturing processes.

B. Background of Gabilan Supply Chain Process

Gabilan operates under a variable demand and constant lead-time system (i.e., they count inventory and push manufacturing orders downstream weekly) in which lead-time (L) equals the review period (T) and we assume that the variability in lead-time is effectively zero (Tersine, 1998; pp.215-216). They build production planning and raw inventory ordering decisions based upon a demand forecasting schedule provided by their customer. It takes approximately 3 weeks to fully construct a muffler from raw material and transport it to a location where it can be consumed (see Figure 1 below).

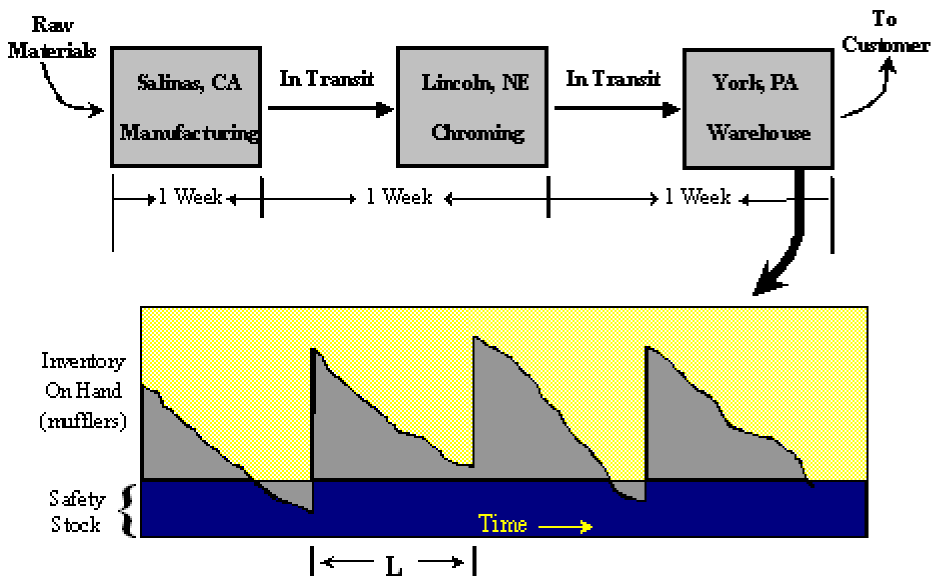

Figure 1. Finished Goods Supply Chain

Since all forecasts exhibit variability, ripple effects, commonly known as the bullwhip effect, are sent upstream to suppliers. Gabilan must acknowledge and react to demand and forecast variability, making sensible decisions that will impact costs and customer service level. Some impacts of the bullwhip effect are excessive finished goods inventories, inefficient utilization of capacity, excessive raw materials cost and additional transportation costs. An important observable aspect of any forecasts is that accuracy tends to decrease as the forecast time-horizon increases. How much that accuracy changes with time is important to a firm and will impact internal planning and operations. The lead-time for ordering raw materials, which can be lengthy the production schedule and the length of the finished goods supply chain are three manufacturing chores affected by the demand forecast (Zhao, Xie & Wei, 2002).

One way this supply chain attempts to avoid the impact of forecast variability is through information sharing. Gabilan and its customer are a good example of a true information sharing relationship. Gabilan retrieves its customer's 16-week forecasted demand schedule weekly through a secure website. This information is then fed into a Manufacturing Resource Planning

(MRP) system and utilized for those manufacturing chores listed above. Figure 1 above illustrates the finished goods (muffler) supply chain as it exists between Gabilan and its customer. As you can see, there exists a 3 week lead-time from the start of Gabilan's manufacturing process to the finished good being available for consumption at the customer's manufacturing site. Demand met at time ***t*** is ready for shipment from Gabilan at time ***t-3***. In reality, mufflers are received at York three times per week. For simplicity and to match recorded data, one-week time frames were studied. Therefore, in our model, York receives one shipment of mufflers (replacement stock) at the beginning of the week to meet that week's demand. The mufflers are then sequenced for a just-in-time delivery to the customer from the York warehouse (henceforth referred to as the warehouse). Based upon the total supply chain cycle time, the four-week forecast becomes critical.

However, it is also important to note that due to planning and production resource scheduling, forecasts beyond the four-week are used as inputs to the production system. The ordering of raw materials must be planned and executed well in advance of the manufacturing start date. Gabilan must therefore rely heavily on eight, ten and twelve-week forecasts. Table 1 shows the correlation between the forecast week number and the utility within Gabilan's planning hierarchy.

Forecast Week	Planning Action
1	At York Warehouse Available to
2	In Transit
3	At Lincoln Facility Chroming
4	Begin Production Salinas
5	
6	Order Raw materials (fiberglass)
7	
8	Order Raw materials (stampings)
9	
10	Order Raw Materials (core tubes)
11	
12	Order Raw Materials (forgings)

Table 1. Typical Gabilan Lead-times

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III. DEMAND FORECASTING ANALYSIS

A. Forecast Error Analysis

It is impossible to perfectly predict future demand values. However, it is paramount to the success of the business that managers understand that the forecast deviates from real values. Gabilan managers suspected that a forecast error existed, but did not know the magnitude of that error. Figure 2 provides an example of the week 8 forecast compared to Gabilan's real demand over that same period of time. The figure shows that there is a significance difference between what the customer has predicted demand will be and what demand actually is 8 weeks later.

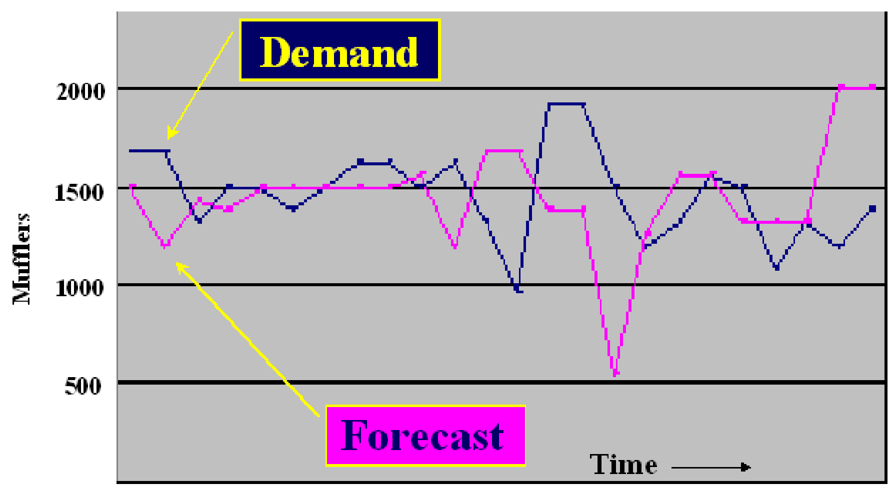

Figure 2. Demand Forecast and Demand versus Time

This analysis focused on seven Stock Keeping Units (SKUs) that make up approximately 85 percent of Gabilan's total demand volume. Due to the size of Gabilan's MRP files, the necessary information was transferred for study into manageable Microsoft Excel® files for ease of manipulation. It was later determined that the use of Microsoft Excel® Macro programs facilitated the transfer and saved significant data entry time. Each file was named for its applicable SKU and a sample of the raw data used in the analysis is shown in

Appendix B1. The information can then be used to show the differences in forecast-week accuracy, offering critical planning and planning horizon information to Gabilan managers. The forecast data changes every week, and as expected, the forecast variability decreases as ***t*** approaches. For each forecast week, accuracy statistics were measured as shown in Appendix B2. The two statistics listed below were used to measure forecast accuracy (Mean Forecast Error) and to calculate safety stock (Root Mean Squared Error):

- **Mean Forecast Error (MFE),** a measure of bias, indicating the direction of the forecast error. An unbiased forecast has errors that fluctuate randomly above and below zero. A positive bias indicates a tendency for the forecast to over forecast, while a negative bias indicates a tendency for the forecast to under forecast. The bias is given by,

$$\mathbf{MFE = \sum (D_i - F_i) / n}$$

Where $\mathbf{D_i}$ is the realized demand at time **i**,
and $\mathbf{F_i}$ is the forecast for the demand at time **i.**

- **Root Mean Squared Error (RMSE),** indicates standard deviation of the forecast error. RMSE is the standard deviation estimator, or standard deviation of the forecast error (σ_e), used in determining safety stock. This term is used versus the standard deviation of lead-time demand because the forecasting process introduces sampling error into the estimation process and is therefore higher than the demand variance. RMSE is given by,

$$\mathbf{RMSE = SQRT\ (MSE)}$$

The individual forecast errors are useful, but it was the summary statistics and graphical representations of those statistics found in Appendix B2 that provided the most valuable error analysis. The forecast bias, as well as other

forecast performance measures listed above, was tabulated for the seven SKUs over the entire 16-week forecast (the statistics were generated from a two-year history of data). Looking across the seven SKUs analyzed, the forecast accuracy significantly decreases at forecast week 6 and continues to deteriorate through week 17. This is crucial due to Gabilan's planning horizon – as procurement and productions decisions are made using week 6 through 12 forecasts.

Figure 3 below, summary statistics for SKU 65413-00, is a good example of the trends found in all seven SKUs and is used throughout the rest of this analysis as the representative SKU. One can see from the highlighted rows in week 5 and 6, there exists a large difference between the mean errors, indicating a major shift in the forecast bias (tendency). In this case, the bias is negative and represents a forecast that consistently underestimates demand. Left unchecked, a system plagued with negative bias could drain inventory levels and cause stock-outs. In order to use any forecast past week 5, Gabilan should account for the bias by adjusting the production input signal. An attempt at this is made when Gabilan management "smoothes" the forecast to level-load production by freezes the production schedule while also accounting for quality fall-out. This qualitative technique is discussed later in the analysis.

Examination of the week-8 forecast in Figure 3 reveals Gabilan would need to add 96 mufflers to the production input number. This would then cause the MFE of the production input to oscillate about zero, the condition of zero bias. It is also important to note here that the analysis was performed on a range of data spanning approximately 2 years. It may be necessary to use averages and other error statistics as they exist over shorter ranges, excluding periods of unusual activity (such as model year change over in the case of Gabilan).

65413-00 Summary Statistics										
Wk	MFE	MAD	MSE or Variance	RMSE	%Error	MAPE	TS	MFE	Plus 3 SD's	Minus 3 SD's
1	29.95	102.18	34365.72	185.38	0.03	0.07	23.16	29.95	586.09	-526.19
2	4.00	116.46	37585.56	193.87	0.00	0.08	2.68	4.00	585.61	-577.61
3	6.96	132.57	38384.36	195.92	0.03	0.09	4.04	6.96	594.72	-580.80
4	-8.99	155.20	48663.01	220.60	0.03	0.10	-4.40	-8.99	652.80	-670.78
5	6.21	162.27	55044.91	234.62	0.00	0.11	2.87	6.21	710.06	-697.64
6	-33.85	199.50	75667.88	275.08	0.00	0.14	-12.56	-33.85	791.38	-859.08
7	-72.85	241.10	120087.56	346.54	0.02	0.16	-22.06	-72.85	966.76	-1112.46
8	-95.89	318.14	215699.58	464.43	0.01	0.22	-21.70	-95.89	1297.42	-1489.19
9	-108.93	292.99	187553.49	433.07	0.02	0.20	-26.40	-108.93	1190.29	-1408.15
10	-133.97	337.80	249432.83	499.43	0.02	0.24	-27.76	-133.97	1364.33	-1632.27
11	-185.65	371.97	367071.71	605.86	0.07	0.24	-34.44	-185.65	1631.94	-2003.25
12	-153.07	317.01	204043.72	451.71	0.02	0.22	-32.83	-153.07	1202.07	-1508.21
13	-148.51	315.01	200198.63	447.44	0.02	0.22	-31.59	-148.51	1193.80	-1490.82
14	-141.00	348.82	221146.15	470.26	0.52	0.23	-26.68	-141.00	1269.78	-1551.78
15	-186.82	365.92	208141.62	456.23	0.61	0.24	-33.18	-186.82	1181.86	-1555.50
16	-209.42	400.48	265304.27	515.08	0.61	0.27	-33.47	-209.42	1335.81	-1754.65
17	-365.13	460.62	278263.38	527.51	0.58	0.28	-51.05	-365.13	1217.39	-1947.65

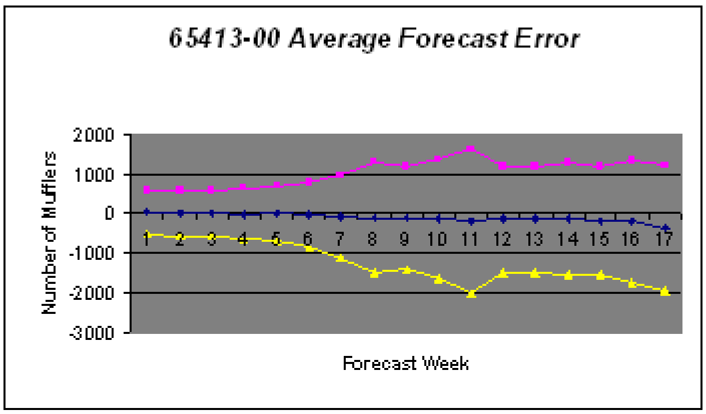

Figure 3. SKU 65413-00 Forecast Summary Statistics

NOTE: SKU 65413-00 makes up 18 percent of the total production for Gabilan at approximately 1,900 mufflers per week.

This forecast performance information adds management value in many ways. First, it offers a method to quantify planning lead times and it clearly illustrates the relative cost of doing business using any week's forecast information. For instance, if Gabilan could use data from a forecast week closer to actual demand (more accurate data) in their production planning, they would induce less variability through forecast error into their system. This not only makes planning easier, it reduces inventory holding requirements and the need

to expedite mufflers to the warehouse at the last minute. Secondly, the information regarding the accuracy of their customer's forecast data can be used for negotiating (renegotiating) delivery contracts and/or service level requirements. Thirdly from *Little's Law*, it is known that when the cycle time of a process is reduced, the average inventory within that system will also be reduced. Therefore, if Gabilan can reduce their internal production cycle time or supply chain lead-time, they could plan using earlier and more reliable forecast data. Finally, it is necessary to monitor accuracy to ensure the forecast is behaving within specified bounds. The most important measure to control is the forecast bias, which should not stray too far from zero. If there is any indication that the forecast is trending in one direction (under or over forecast) for a period of time, the source or method of the forecast should be questioned.

Another useful statistic measuring the forecast error is the tracking signal. Since the forecast error should be cycling about zero, the tracking signal should be generally small also. The limits of this statistic should be set by Gabilan managers and carefully monitored to avoid severe under or over-forecasting conditions (Chase, Aquelino, Jacobs, 2001).

B. Safety Stock and Production Input Analysis

A proper understanding of forecast variability will also lead to improved calculations of finished goods inventory levels as well as ordering levels of raw materials. Since Gabilan is the sole provider of mufflers to its customer, it must provide as close to 100% service level as possible (if finished mufflers stock-out, the motorcycle manufacturing line stalls), making up for potential "stock-out" conditions with expeditious transportation. Demand uncertainty coupled with high service level plays the lead role triggering Gabilan to store inventory.

It takes time to manufacture products and transfer them to the consumer. It is only by chance that what a firm manufactures today will perfectly meet consumer demand at some future time. It is therefore necessary for a firm to make the "best" manufacturing input decision; a decision to produce a quantity most closely matching future demand. It is also necessary for a firm to decide on

the most cost-effective quantities of safety stock based upon forecast error statistics. Safety stock is intended to hedge against the difference between demand variability and the manufacturing input decision. “Bad” forecast information causes either excessive or sparse production, leading to inefficient inventory levels downstream. The first decision to make is the correct safety stock level necessary to overcome the impact of forecast error at Gabilan.

Since Gabilan operates under a *variable demand and constant lead-time* system, the goal of safety stock is to simply cover variability in average demand during lead-time. Assuming the demand is normal, demand would equal to the average or below 50% of the time. Therefore, the amount of safety stock would be directly related to the service level decision and the demand variability, covering Gabilan for instances when the average demand is greater than 50% (see Figure 4 below). Of course, service level provided by safety stock alone could not be 100% without suffering an extremely large penalty for inventory cost. This why a service level decision must be made, balancing the cost of added inventory with the cost of expediting. The analysis made in the following pages should aid in that decision.

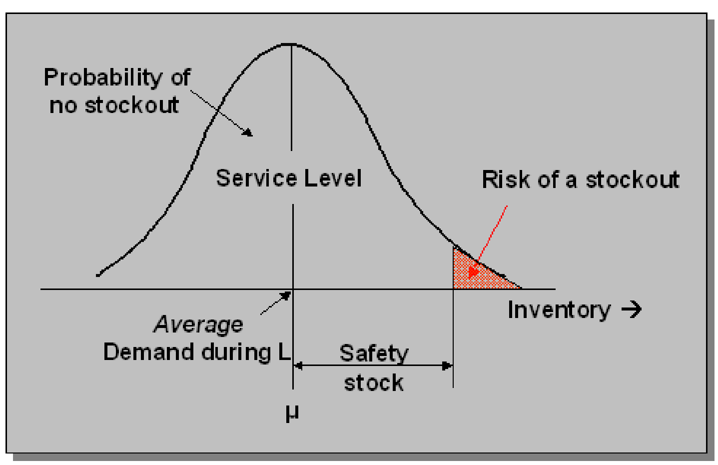

Figure 4. Normal Distribution of Demand During Lead-Time

C. Recommended Safety Stock vs. Actual Safety Stock Held

It is first necessary to derive a recommended safety stock level and compare it to what Gabilan is currently holding as safety stock. In order to provide an accurate interpretation of current safety stock requirements, year 2003 data was used from Appendices B1 and B2 only. The safety stock calculation was modified from the base equation to the revised equation below to reflect Gabilan's actual operating environment:

- **Safety Stock = Z * σ_L * SQRT (L)** **Base Equation**
- **Safety Stock = Z * σ_E * SQRT (L)** **Revised Equation**

Where Z is the Z-score based upon the service level decision,
σ_L is the standard deviation of the lead-time demand,
σ_E is the standard deviation of the forecasting error (σ_E is 303 from Appendix B4), and
L is the lead-time from placing an order to receipt of that order

The revised safety stock equation was used because it more accurately reflected Gabilan's reliance on forecast data. Gabilan decides what to produce based upon the forecast information, not based on past demand information. The standard deviation for the forecast error was always greater than that of the demand, therefore depicting a more realistic value used in determining safety stock. Using the revised equation above, the theoretical value of safety stock necessary to overcome existing forecast error at Gabilan, assuming a 99% service level was calculated to be (Nahmias, 1997; pp. 145):

- **Safety Stock = Z * σ_E * SQRT (L)** **Revised Equation**
- **Safety Stock = (2.33) * (303) * SQRT (3)**
- **Safety Stock = 1221**

It was then necessary to determine the existing safety stock within Gabilan's supply chain. Since the recorded data precluded the direct calculation of a

figure, a few assumptions were made. First, any inventory within one day of transportation from the end warehouse at York was considered available to meet customer demand. This included all inventory at York, in-transit York and 50% of the inventory held at Lincoln, Nebraska, all within one day of York. Table 2 below shows actual inventory values and derived average safety stock for Gabilan. Again, SKU 65413-00 was used for illustration purposes, while two additional SKUs (65538-95A and 65890-00) were included in Appendices B3 through B6. The realized safety stock shown in Table 2 was 1719, approximately 500 Mufflers greater than the theoretical value. This 30% difference represents potential savings in the form of safety stock reduction for one SKU.

Year 2003 Week #	Lincoln Balance MONDAY	Total On Hand & In Trnst	ACTUAL DEMAND THIS WEEK	Realized Safety Stock
1	2283	2993	1800	1193
2	3223	2467	1800	667
3	3409	2430	1800	630
4	3175	2470	1440	1030
5	3135	2617	1800	817
6	3321	3024	1440	1584
7	3419	3453	1440	2013
8	4125	3894	1800	2094
9	3560	3691	1500	2191
10	3294	4117	1860	2257
11	3642	3974	1920	2054
12	3208	3986	1860	2126
13	3987	3389	1628	1761
14	4595	3381	1638	1743
15	4514	2927	1288	1639
16	4573	3254	1610	1644
17	4938	3468	1654	1814
18	4953	3476	1690	1786
19	5644	3830	1662	2168
20	5859	4150	1646	2504
21	6162	4350	1426	2924
22	6512	3947	1800	2147
23	5489	3779	1806	1973
24	4451	2855	1804	1051
25	4510	2611	1952	659
26	4135	3572	1504	2068
27	2215	4091	1736	2355
28	4630	4318	1948	2370
29	2000	3000	1750	1250
30	903	3592	2127	1465
31	3228	3440	2123	1317
			Average	**1719**

Table 2. Actual Inventory Values and Derived Safety Stock for 65413-00

D. Validating Safety Stock Calculations and Providing Alternative Production Input Signals

The safety stock calculations above were validated through the development of simple lot-for-lot production models. These models will also offer Gabilan an alternative means to determine a production input signal that more closely represents expected future demand. The lot-for-lot technique sets planned manufacturing orders (signal input) exactly equal to what is the expected requirement (Chase, Aquilano, Jacobs, 1997). The "uniqueness" of each model is the production signal input. Each model uses a different production signal input: (1) last period's demand, (2) the eight-week forecast, (3) the corrected (for forecast bias) eight-week forecast, and (4) Gabilan's real historical input. Model 4 was designed to then test the validity of Gabilan's derived safety stock of 1719 units. All models were "primed" with a York inventory equal to the calculated safety stock plus average weekly demand and assumed a constant six percent quality-defect rate. The four models are shown in Appendices B3 through B6.

In an ideal situation, safety stock should be the quantity left over in the warehouse after demand is. Therefore, the primary output of the models was the average inventory remaining at York after demand is satisfied, or what should be a close approximation of safety stock. Another measure of the model's performance was the average error between input signal and realized demand some time in the future and the standard deviation of that error (or Root Mean Squared Error). Also measured was the number of stock-outs, or the number of times the inventory remaining at York was negative. The four models were run and recorded with the results shown in Table 3 below:

Model #	Manufacturing Input Signal	Average Inventory At York	Average Forecast Error	Number of Expediting Occasions (Stock outs)
1	Previous Week's Demand	851	-28	2
2	8 Week Forecast	878	-8	0
3	Corrected 8 Week Forecast	1043	0	0
4	Gabilan Historical	1723	-25	0

Table 3. Model Simulation Output

From Table 3, it can be shown that the least amount of inventory with no stock outs was achieved under these conditions using model 2. Model 3 simply corrected for the average forecast error of model 2 by either adding or subtracting the error quantity from the input signal, thereby resulting in zero forecast error. Correcting for this bias under model 3 led to an increase in average inventory. On the other hand, it did yield signal inputs that were smoother than model 2. In the long run, it is believed model 3 will produce the best results, both in a smooth input signal and a lower inventory level at York. As a validation, model 4 yielded an average York inventory that closely matched historical figure of 1719 as stated previously.

E. Conclusions

Real world manufacturing decisions should be made with as accurate information as possible. This is why an analysis of demand forecasting error is important. Not only does it provide useful data for the firm to feedback to its customer, it also provides vital planning and production information. This analysis has shown how forecasting errors impact production decisions and levels of inventory. In a perfect world, forecast information would perfectly match production input, which would then perfectly match customer demand. A situation close to this would exist if Gabilan's customer would freeze their demand by the forecast amount. In other words, if the customer would "buy" exactly what they forecasted, both the inventory of raw materials needed and the

inventory of finished goods would significantly decrease. In the world as it exists today however, there is forecast variability and the amount of variability increases as the forecast time horizon increases. The analysis illustrates the complex interactions between forecast variability and demand. It is therefore recommended that Gabilan use model 3 contained in Appendix B5 together with their current mode of operation. If the model continues to yield accurate results, it should be considered for future production input planning. It is expected that the overall analysis will provide a helpful approach to Gabilan managers in their endeavors to improve supply chain effectiveness.

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IV. CAPITAL INVESTMENT AND CAPACITY

A. Overview – Literature Review

One of the key issues Gabilan Manufacturing, Inc. requested was that an analysis be conducted on the possible acquisition of an advanced technological solution for their cutting process. While this analysis primarily focuses on the tangible cost savings associated with that, and other alternatives, for Gabilan's cutting process, it is worth recognizing at the outset that a number of potentially important factors are ignored in such a quantitative analysis. A recent review by Saleh & Hacker (2001) identifies key attributes manufacturing organizations consider when evaluating factors in capital decisions for advanced manufacturing technologies. The decision to invest in automation to replace an existing system requires the evaluation of both tangible (quantitative) and intangible (qualitative) benefits. Siha and Linn (1989), Kaplan (1986), and Canada (1985) identify some of the potential benefits of the added value of capital investment in advanced manufacturing technologies. These are: flexibility, compatibility, learning process, training, quality, capacity, inventory, throughput and lead times and safety and floor space. While the primary analysis will focus on cost implications, some of these qualitative factors will be discussed in the next section.

The analysis in sections 4 and 5 revolve around Gabilan's steel-tube cutting operation and among the many attributes involved in this cutting processes, quality is a primary concern because it significantly impacts the assembly phase. As reported by Hill (1991), Lyons (1991), and Park and Son (1988), improved product quality is the key factor in advanced manufacturing systems and plays an important role in improving the market share and profit margin of a manufacturing company by decreasing the total manufacturing cost. This is congruent with the analysis of Gabilan's scrap material and rework levels in the various cutting alternatives, which shows significant savings that might be obtained by the right technological solution.

B. Background of Gabilan Cutting Process

Gabilan's business has experienced significant growth over the last few years and the expectation is that this trend will continue. In addition to normal business growth, Gabilan's only customer has recently changed from a mass production process to a lean manufacturing process. This change significantly impacted all of the motorcycle manufacturer's suppliers. With this new production process, the motorcycle manufacturer's suppliers are now required to provide components to the manufacturing plant just in time and in a specified order arranged by the motorcycle manufacturer's production schedule. The motorcycle manufacturer has also required its suppliers to find ways to improve business practices in order to reduce the cost of materials supplied to the motorcycle manufacturer. These factors have resulted in considerable strain to Gabilan's processes. In order to achieve the required cost savings, Gabilan is considering the purchase of additional capital in order to increase the cutting capacity of twenty-foot steel-tubing material in order to alleviate the strain. The questions addressed here are whether a new machine should be purchased and where the perforated tube cutting operation should be located.

C. Current Process

Raw material is currently purchased from Valmont (Central Nebraska Tubing) in Waverly, Nebraska. The raw material is shipped 1700 miles to Gabilan Manufacturing Incorporated-Salinas (GMIS) where it is cut into smaller components. These components are formed, shaped, bent, welded and assembled to specification within an outer shell to form a muffler. The manufactured mufflers are then shipped to Gabilan Manufacturing Incorporated-Lincoln (GMIL) in Lincoln, Nebraska where the mufflers undergo a chroming process at Lincoln Plating which, according to its web page, is "one of the nation's largest and most diverse metal finishing companies." Upon completion of the chroming process, the mufflers are then shipped to one of two locations, the Kansas City Motorcycle assembly plant or Gabilan Manufacturing Incorporated-Emigsville (GMIE), in Emigsville, Pennsylvania. The mufflers shipped to Kansas

City are packaged in a specific order to arrive just in time for assembly in the plant. The mufflers shipped to Emigsville are packaged for storage in the GMIE warehouse. When the York, Pennsylvania motorcycle manufacturing plant places an order for mufflers, the mufflers are then packaged in a specific order and delivered just in time for the assembly process in the York motorcycle assembly plant a few miles away. This process is shown in Figure 5 below.

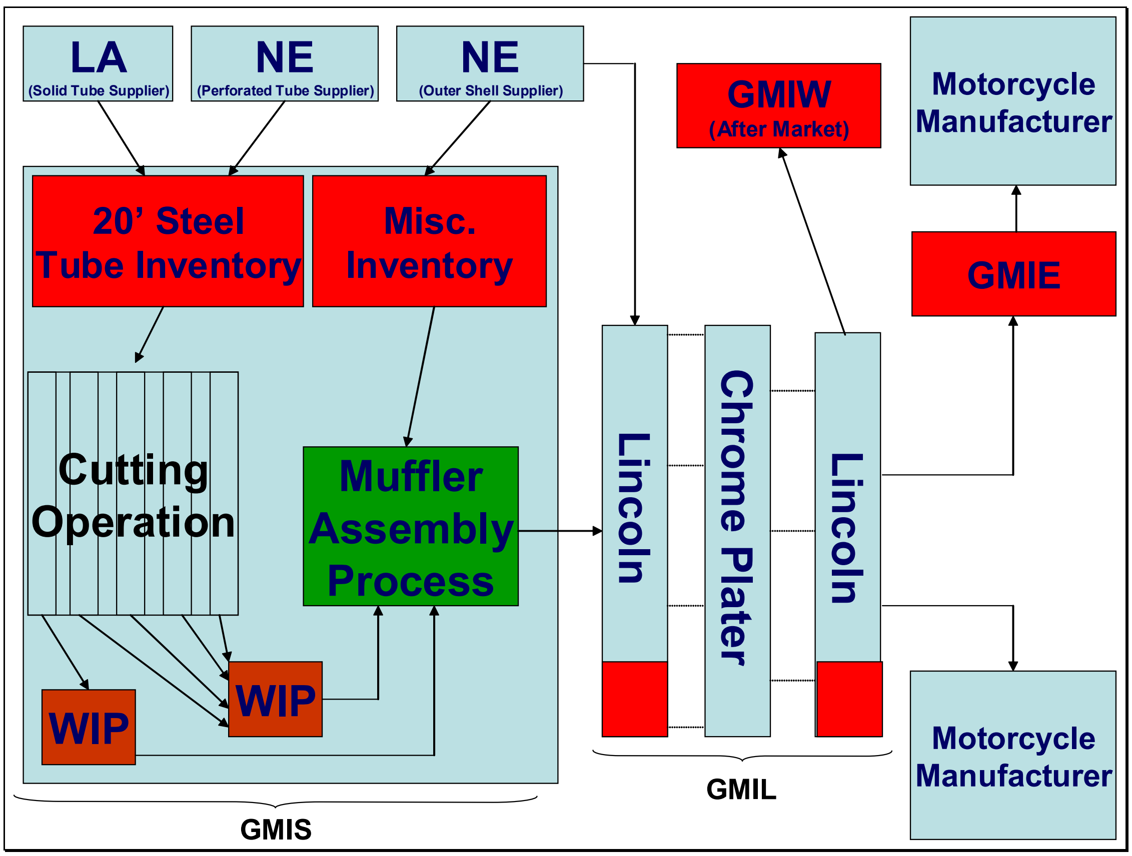

Figure 5. Muffler Assembly Process

Currently Gabilan uses five cutting machines to process twenty-foot lengths of steel tubing into smaller component parts. These machines are the Modern cutter, the KMT saw, the Cold saw, the Shear cutter and the Roll cutter. The Modern cutter is used primarily to cut non-perforated (solid) steel tubes. The

KMT saw is used primarily to cut screen steel tubes. The remaining three cutters are primarily used to cut perforated steel tubes.

- **Modern Cutter –** The Modern cutting machine is used to cut non-perforated (solid) tubing. It is a self-feeding, automated machine that provides a large number of repeating cuts to specification in a short period of time. The Modern cutter's high throughput rate is its main strength, but this cutter also provides a lathe type cut of high quality that is instrumental in downstream forming processes. The drawback to this machine is that it cannot adjust to cutting perforated tubing in such a manner that the resulting cut pieces are uniform with respect to the perforation pattern. This is partly because perforated tubing undergoes stretching during its manufacturing process. In addition, because of the way the perforated material is cut into twenty-foot lengths at the mill, the perforated pattern starts at different distances from the end of the twenty-foot tube. This makes the Modern cutter unsuitable for most perforated tube cutting.
- **KMT Saw –** The KMT is a rotary-blade-saw that provides a mill cut. It is used by Gabilan Manufacturing, Inc. to cut screen-tubing material in order to alleviate the volume of material going through the Cold Saw. The KMT saw provides adequate cutting for the screen material because the screen components do not undergo further shaping processes downstream but are primarily used to hold fiberglass in place within the muffler.
- **Cold Saw –** The Cold Saw is a rotary-blade saw that provides a high-quality mill cut. The machine is capable and normally used to cut three perforated tubes at time. The Cold saw requires significant operator involvement to line up each of the perforated tubes manually in order to meet the specifications for the part being manufactured. The Cold saw provides a mill type cut that provides

the quality necessary for downstream forming, bending and welding processes.

- **Shear Cutter –** The Shear cutter provides additional cutting capacity for both perforated and non-perforated material. This is the least preferred cutting method for downstream forming, bending and welding processes and is typically not used for material needing additional downstream processes. This machine requires a great deal of operator involvement as there is no automation. Specifically, this cutter requires an operator to load the twenty-foot tubes, insert each tube into the cutter one-at-a-time, line up the specific perforated pattern on the tube using the naked eye and finally operate the shear with a foot-pedal device.
- **Roll Cutter –** The Roll cutter is the perforated tube-cutting workhorse. This particular cutter is a manual, lathe-type cutter that requires an operator to line up the tube to specification and operate the cutting device. This cutter provides a lathe-type cut similar to the Modern cutter, but it does not provide the consistent quality of cut necessary for downstream forming, bending and welding processes.

D. Methodology

First, the actual cutting performed during a two-month period was compared to the theoretical capacity of each machine. The actual production numbers were obtained from the production logs for the months of June and July 2003. The production logs documented which machine was used and how many pieces were cut on that machine each day. From that information, the utilization rate of each machine was determined. That utilization rate was then translated into a cost-of-operations based on man-hours used to achieve that utilization.

It is understood that because the operators manually maintain the production logs, the data is not perfect. Representatives from Gabilan have stated that the logs may be overstated at times by as much as 20 percent per

part number cut. In this study the logs are taken at face value because no other method is available whereby these exaggerations can be isolated and adjusted. This means capacity calculations in this study may be slightly overstated. The second part of this study examined the cost of the cutting operation in relation to where that operation is performed. This was calculated in terms of labor costs and transportation costs. Labor costs were determined based on standard hourly rates (not including labor-burden) based on the rates in each particular location. Transportation costs were determined based on price-per-mile as provided by Gabilan. While the price-per-mile is not variable, the number of shipments is variable because the number of shipments is directly related to the amount of manufacturing drop (waste) created as a result of the screen and perforated tube-cutting operation. If the screen and perforated tube-cutting operations are performed in a different location than the muffler manufacturing/assembly operation, the manufacturing drop (waste) is not shipped and a cost savings may be realized. No discrete information on waste from the screen and perforated-tube cutting process was being maintained by Gabilan, so a mathematical model was developed to determine the amount of perforated and screen raw material wasted. Gabilan maintained a monthly raw materials inventory. Receipts throughout the month were added to the beginning inventory to provide the total amount of inventory available. In order to calculate the amount of material used in the cutting operation, the ending inventory balance was subtracted out from the amount of inventory available calculated above. The difference is the actual inventory used throughout the month in the cutting operation. Subtracting the amount of finished goods produced from the cutting operation (as documented in the production logs) from the amount of inventory used to create those finished goods provided a measure of total waste produced as a result of the cutting process. This waste was then translated to a dollar-value and potential cost-savings by associating the waste with shipping costs.

V. PERFORATED TUBE CUTTING ANALYSIS

A. Capacity Determination

The data for each cutting machine was captured for all days worked during a two-month period. Appendices C1 and C2 provide a sample of the compilation of data obtained from the actual production logs for the months of June and July. The logs record actual production of parts during the two months observed. Table 4 below provides a brief summary of the information contained in Appendices C1 and C2.

Name of Cutter	Theoretical Rate (pieces/day)	Average Realized Cutting Rate (pieces/day)	Realized Utilization
Modern	16,000	7,840	49%
KMT	1,200	792	66%
Cold	3,200	1,600	50%
Shear	8,000	4,440	55.5%
Roll	3,200	2,240	70%

Table 4. Theoretical and Average Cutting Rates

Appendices C3 and C4 provide the amount of raw material used in the cutting process for the months of June and July. These are derived by taking the previous month's closing raw material inventories, adding the current month's receipts and subtracting the current month's ending inventory. These figures are used to calculate the amount of manufacturing drop (waste) that is accumulated by the cutting operations during each month.

Appendices C1 and C2 provide the actual amount of good material cut for the months of June and July. This is derived by using the actual number of pieces cut by part number and multiplying it by the length of the piece based on the specifications provided by manufacturing blueprints developed by Gabilan. The amount of good material is subtracted from the amount of material available for processing and provides the total manufacturing drop (waste), as an

aggregate, for the months of June and July. The percentage of drop is shown in Table 5 below:

June	Used (ft)	Cut (ft)	Difference	% Drop
Perf.	129,242	96,070	33,172	25.67%
Screen	74,366	62,078	12,288	16.52%
July				
Perf.	127,070	106,193	20,877	16.43%
Screen	76,658	59,020	17,638	23.01%
		Total		
Perf.	256,312	202,263	54,049	21.09%
Screen	151,024	121,098	29,926	19.82%

Table 5. Total Manufacturing Drop

Appendix C5 shows the compilation of inventories spanning twelve months. These inventories are used to determine average on-hand quantities per month as well as to determine the weighted average cost of perforated material, screen material and non-perforated material as summarized in Table 6 below.

	Feet	Total Dollar Value	Cost per Foot
Monthly Avg. Inventory Perforated Tube	217,630	$185,803	$0.853756
Monthly Avg. Inventory Screen Tube	64,136	$71,982	$1.122334
Monthly Avg. Inventory Non-Perforated Tube	66,980	$46,260	$0.690654
Total Monthly Average Inventory	348,746	$304,045	$0.871824

Table 6. Perforated Tube Cost Per Foot

B. Cost Comparison Analysis

Appendix C6 provides the operating costs baseline of the steel-tube cutting operation associated with the current business practices performed in Salinas, California. Information on labor costs and transportation rates are based

on current data provided by Gabilan. Inputs to the model are programmed man-hours, labor rates, actual machine capacities, distance raw materials travel and the cost per mile of that transportation. The model captures the two main drivers that account for the costs of the operation: manual labor and transportation.

Appendix C7 provides the operating costs of conducting business if all perforated and screen tube cutting is moved from Salinas, California to the Gabilan facility located in Lincoln, Nebraska. Table 7 summarizes the results of the comparison between current operations and moving the perforated and screen cutting operation to Lincoln, Nebraska.

Moving Cutting Operation from Salinas to Lincoln (no new equipment)	Salinas	Lincoln	Savings
Manpower Cost for Cutting:	$266,380	$243,746	$22,634
Transportation Costs:	$106,250	$85,221	$21,029
Total Costs:	$372,630	$328,967	$43,663

Table 7. Comparison of Moving Operations

A careful look at Table 7 clearly shows a change in annual costs due to the lower labor rates in Lincoln over Salinas. Additionally there is a potential reduction in transportation costs when conducting the cutting operation in Lincoln because the manufacturing drop (waste) from the cutting process is not being shipped to Salinas. Some of the total savings, however, will be offset by investment in packaging materials necessary to transport cut material from Lincoln to Salinas.

In addition to the cost savings mentioned above, the potential also exists for the elimination of on-hand quantities of raw material if all perforated and screen tube cutting is conducted in Lincoln, Nebraska vice Salinas, California. Raw material can be delivered just-in-time for cutting operations in Lincoln because the supplier, Valmont (CNT), is only 19 miles away. As long as an accurate demand forecast for raw materials is provided to Valmont (CNT), a contractual arrangement could be made whereby risk is shared between the two

companies. Valmont (CNT) would be assured that material would be purchased and Gabilan would be assured that the material would be readily available for just-in-time delivery.

There are other factors to be considered that are qualitative vice quantitative in nature. Information sharing between the manufacturing/assembly operations in Salinas and the cutting operation in Nebraska will have to be closely coordinated. Only with proper information sharing and close coordination can Gabilan ensure the proper quantity and type of materials are cut and shipped from Lincoln to Salinas to feed the muffler assembly line. In addition, safety stock levels for each part number will need to be determined. If transportation savings are to be realized, safety stock will have to take into account the additional lead time between shipments that will occur as a result of decreasing the number of dedicated shipments per year.

Another consideration to be examined is flexibility. Under the current system, changeover is relatively simple. If there is a need to change the muffler type that is being manufactured, the appropriate raw material can be pulled and cut to meet the changes in the muffler assembly process. If the cutting operation is conducted in Lincoln, Nebraska, there will be an additional delay in obtaining the new material due to transportation requirements. This increase in time does not need to be as long as might be expected. Several expediting options are available if the manufacturing plant is found in extremis. A fact to consider is that cut pieces will ship in more compact containers. This implies that commercial carriers could expedite cut parts overnight. Gabilan also has muffler outer shell material shipped to Salinas from Valmont twice a week. Although these trucks are generally full, a couple of crates of outer shells could be replaced (if necessary) by cut perforated material to meet production requirements until the cutting operation catches up with the appropriate shipping schedule.

The loss in flexibility must be weighed against the increase in attention the cutting operation will require if it is no longer collocated with production operation. The production schedule determines what component parts are required to

manufacture mufflers. Having the cutting operation collocated with the production plant may actually be hiding inefficiencies. The reason for this is if there is a shortage in materials the cutters can be brought on-line to make up for such deficiencies. This is being reactive vice proactive in managing the material requirements.

C. New Capital Analysis

Gabilan has considered purchasing a new machine, the 3DL-Modern, to increase capacity in the perforated tube-cutting operation. The same manufacturer as the Modern cutter currently being used in Salinas makes the 3DL-Modern. This new machine is fitted with a laser sight device to control alignment in order to cut perforated tubing. The rationale for selecting the 3DL-Modern was the high theoretical capacity exhibited by the current Modern cutter. If the 3DL-Modern cutter could be used effectively to cut perforated material close to the rate of the current machine it would be able to provide significant cost savings to Gabilan.

However, installing the laser sight significantly reduced the theoretical capacity of the 3DL-Modern to 225 pieces an hour. This is only 22.5% of the desired theoretical capacity of the existing Modern cutter. Despite the reduction in theoretical capacity, the original argument still holds: increased theoretical capacity can lead to cost savings. Appendices C8 and C9 provide data for purchase and operation of the 3DL-Modern cutter in Salinas and Lincoln respectively. Table 8 summarizes the findings found in these appendices and compares the results to the baseline cutting operation performed in Salinas.

Moving Cutting Operation from Salinas to Lincoln (with new 3DL-Modern Cutter)	Salinas (Baseline)	Salinas (new cutter)	Savings	Lincoln (new cutter)	Savings
Manpower Costs for Cutting:	$266,380	$234,072	$32,308	$215,062	$51,318
Transportation Costs:	$106,250	$106,250	-	$85,221	$21,029
Total Costs/Savings:	$372,630	$340,322	$32,308	$300,282	$72,348

Table 8. Comparison with New Cutter

A careful analysis of the information in Table 8 shows potential savings are achievable as a result of investing in new capital. In order to achieve the savings, though, this study makes the assumption that Gabilan can obtain at least 70% utilization out of the new equipment. If that level of utilization is obtained, the 3DL-Modern cutter has the capacity to replace two cutters, the Cold saw and the Shear cutter. Essentially, the new 3DL-Modern cutter, operating above a 70% capacity, will replace two machines that are currently being utilized at about 50 percent capacity. The bulk of the savings that can be realized are based primarily on the reduction of labor hours required to perform the cutting operation.

D. Efficiency Analysis

The new capital analysis section above made certain assumptions regarding the efficiency at which the 3DL-Modern cutter could be operated. This section examines what the costs of the cutting operation would be if the current machines were operated more efficiently and the potential savings that can be obtained by improving internal processes to gain the increased levels of efficiency. Appendices C10 and C11 provide data on the costs of the cutting operation if all machines were utilized at 70% in the Salinas location as well as the Lincoln location with these findings summarized in Table 9 below.

Operating at 70% Utilization	Salinas (Baseline)	Salinas (at 70%)	Savings	Lincoln (at 70%)	Savings
Manpower cost for Cutting:	$266,380	$220,409	$45,971	$200,866	$65,514
Transportation Costs:	$106,250	$106,250	-	$85,221	$21,029
Total Costs/Savings:	$372,630	$326,659	$45,971	$286,087	$86,543

Table 9. Comparison at 70% Utilization

A careful observation of the information in Table 9 highlights the fact that the greatest cost savings can be obtained by increasing the efficiency of the existing machines. In all cases observed, the maximum savings obtained in the

cutting operation can be achieved by using the lower labor rates in Lincoln, Nebraska.

E. Risk Analysis

"Risk is often defined as the probability of occurrence of an undesirable outcome" (Evans, 2002; p.6). As it pertains to Gabilan, the undesirable outcome from making decisions based on the information provided in this study is the probability that the scenario chosen will not provide the desired cost savings. More to the point, the undesirable outcome is creating an increase in costs associated with the cutting operation.

"Risk analysis is an approach for developing a comprehensive understanding and awareness of the risk associated with a particular variable of interest" (Evans, 2002; p.113). For Gabilan, this means the variable of interest upon which to conduct a risk analysis is the cost savings resulting when comparing the baseline measure of costs against the costs determined in each scenario. The simulation model used for this analysis is the Monte-Carlo simulation, which is, "a sampling experiment whose purpose is to estimate the distribution of an outcome variable that depends on several probabilistic input variables" (Evans, 2002; p. 6).

Using cost-savings as the risk variable, a Microsoft Excel® spreadsheet model was developed with the add-in tool known as Crystal Ball®. Using that model, assumptions were defined for labor variables and manufacturing drop (waste) and probability distributions were associated with those assumptions in order to capture uncertainty. Because specific data pertaining to the number of man-hours used for each of the cutters was not maintained by Gabilan, the probability function chosen to capture the variability was a triangular distribution. The most likely value for the triangular distribution was based on the average number of hours programmed per week for each cutter. In order to determine the upper limit of the triangular distribution, Gabilan actual average overtime rate of 8% was used. Since no data was maintained on the actual number of hours used for each cutter, the lower limit was determined by using the same

percentage used for overtime and subtracting that value from the weekly average. Therefore an assumption was made on the fact that the distribution of hours worked is symmetrical – that periods of too much work (requiring overtime) are offset by periods of less work. The assumptions made for the assignment of the triangular probability distribution function is provided in Table 10 below.

	Minimum Value	Most Likely Value	Maximum Value
Shear Cutter:	37	40	43
Cold Saw:	74	80	86
Roll Cutter:	74	80	86
KMT Saw:	46	50	54
Modern Cutter:	74	80	86

Table 10. Triangular Distribution Assumptions

After establishing the triangular probability distributions for the assumption cells, the output variable of interest (cost savings) for each scenario was then defined as a forecast cell. With the set-up of the risk model completed (Appendix C12), the simulation was run through 50,000 trials in order to determine the range of cost savings provided by each scenario. The Crystal Ball® output results for each scenario are provided in Figures 6-10 below and are summarized in Table 11.

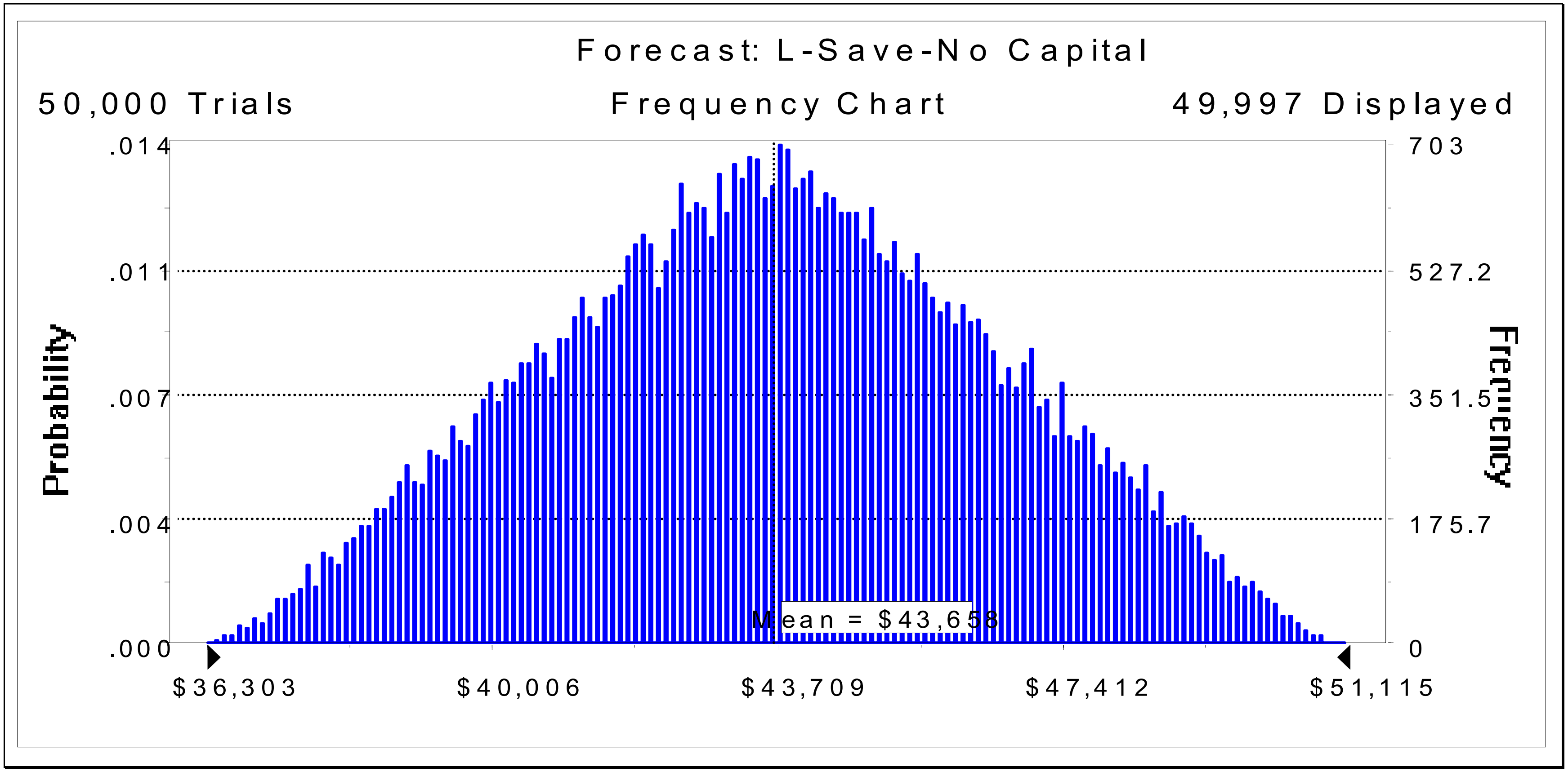

Figure 6. Cutting Operation in Lincoln

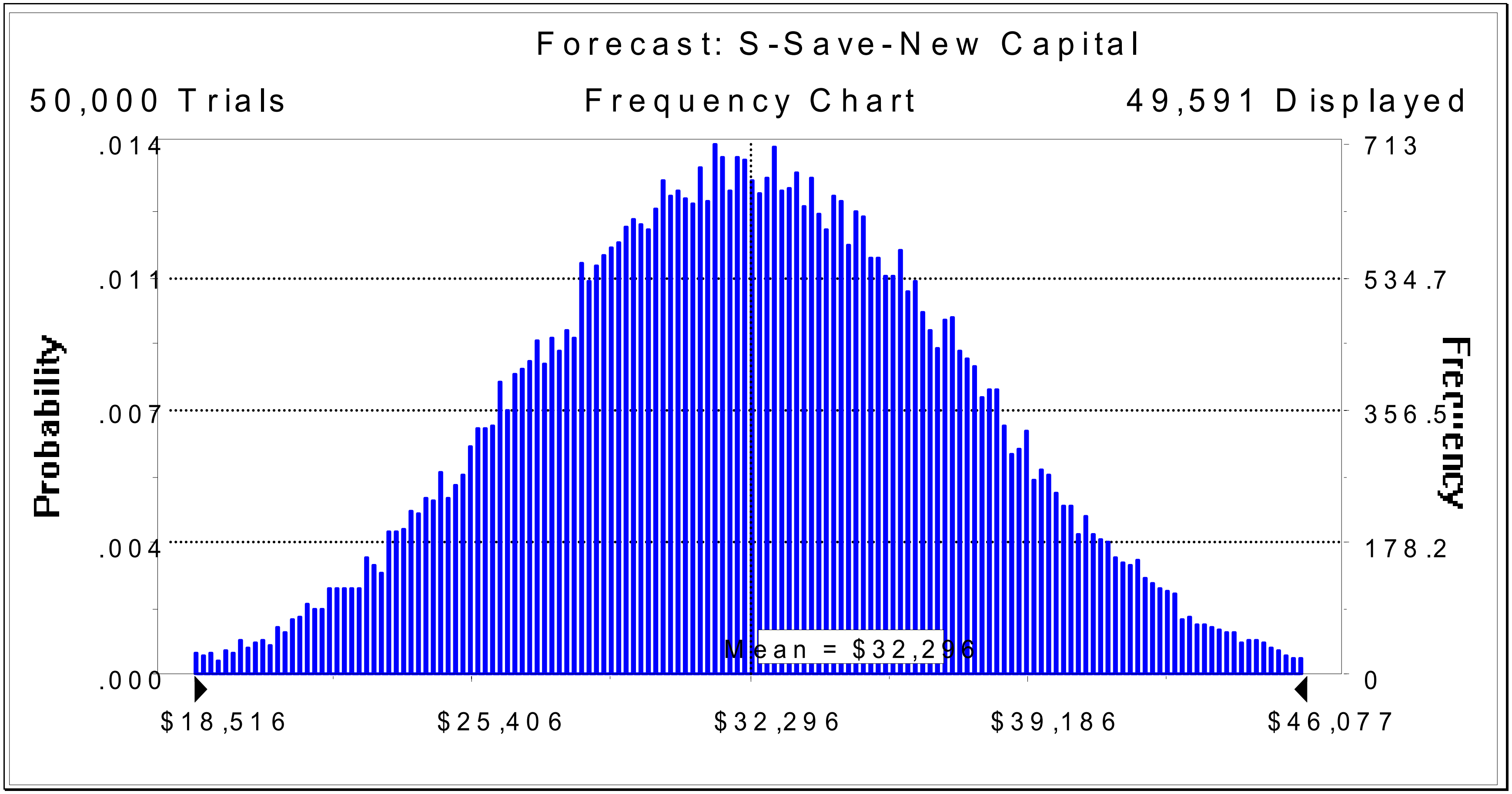

Figure 7. Cutting Operation in Salinas with 3DL-Modern

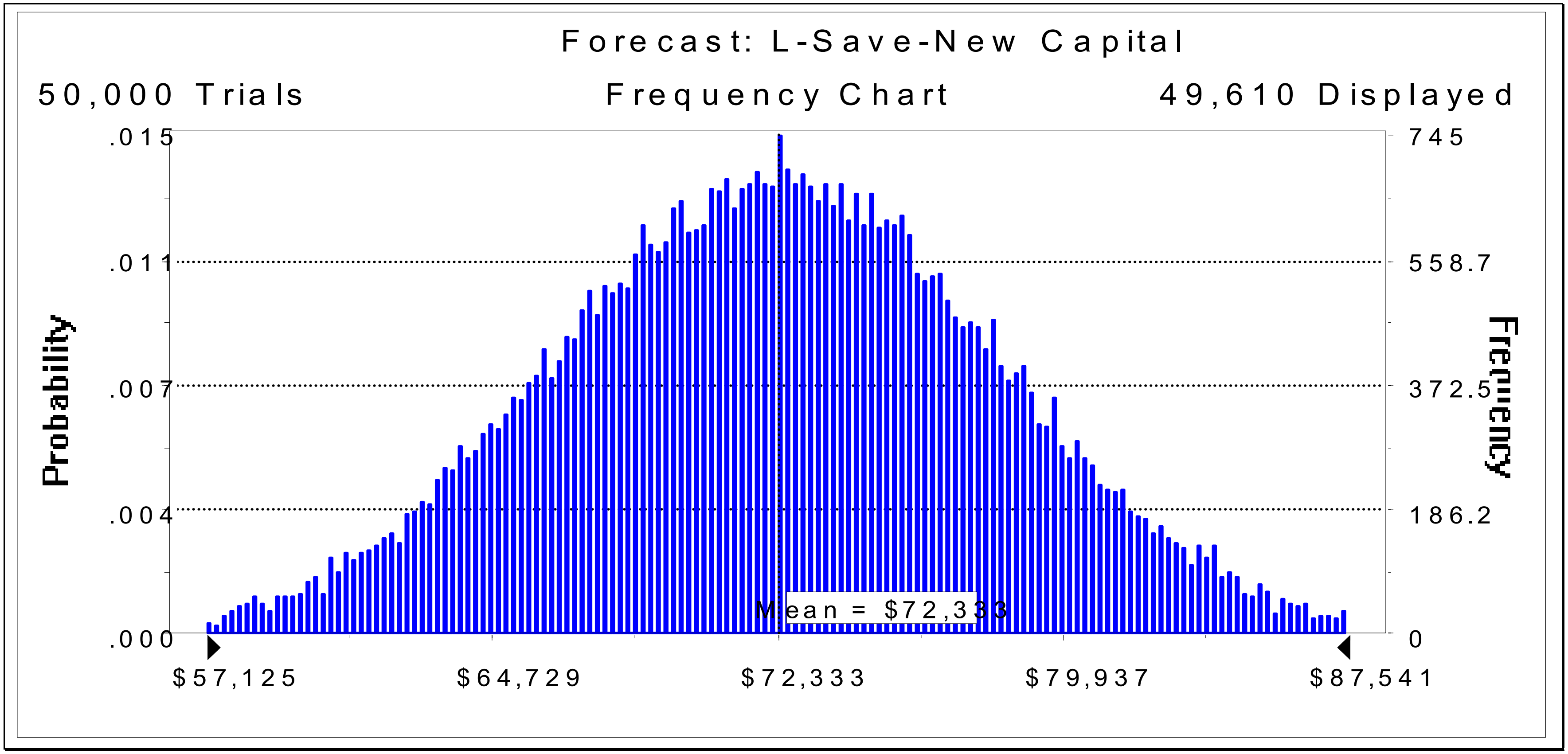

Figure 8. Cutting Operation in Lincoln with 3DL-Modern

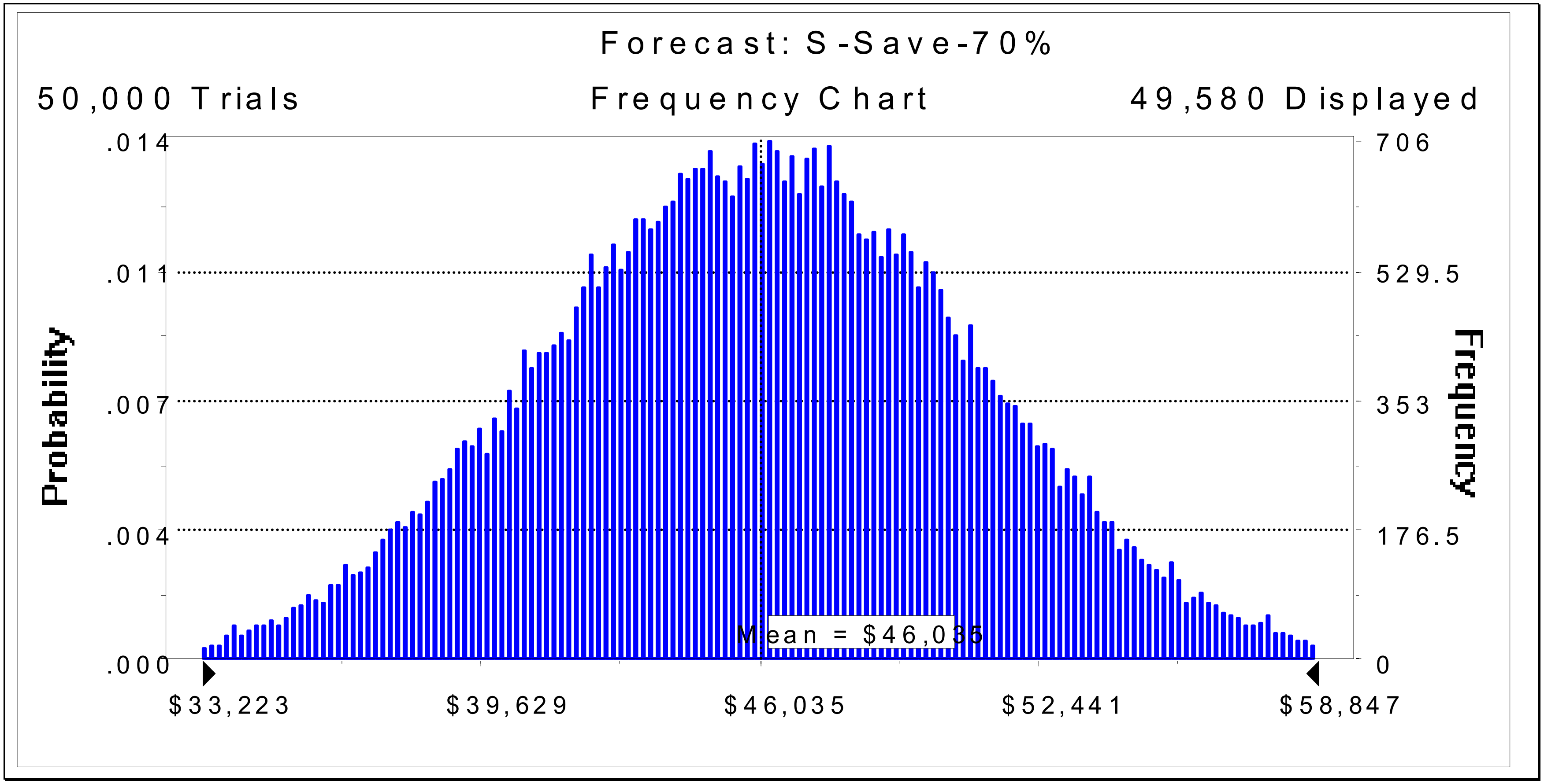

Figure 9. Cutting Operation in Salinas at 70% Utilization

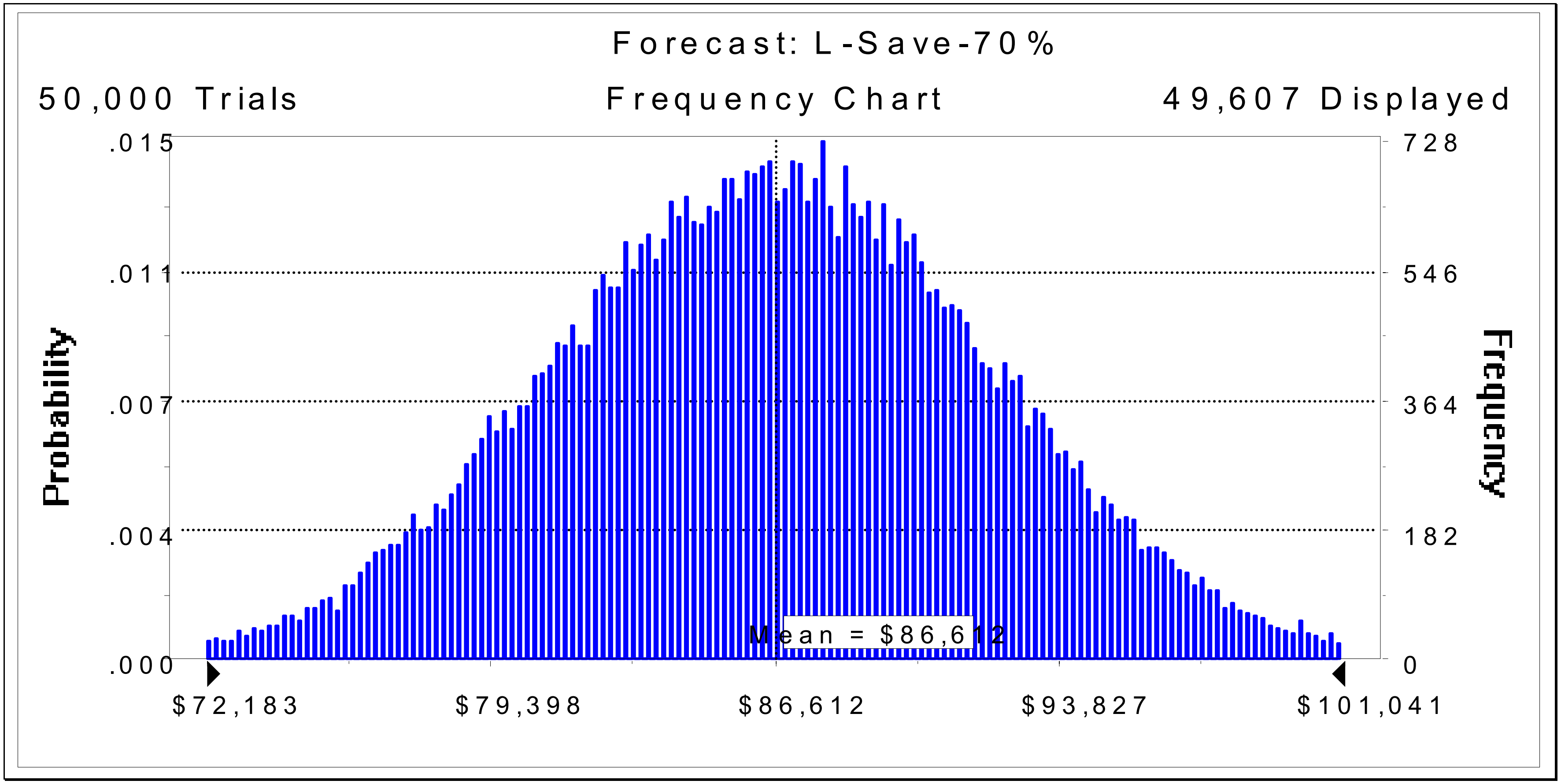

Figure 10. Cutting Operation in Lincoln at 70% Utilization

Cost Savings			
Scenario	Lower Limit	Average	Upper Limit
Lincoln (no new capital):	$36,303	$43,658	$51,115
Salinas (new capital):	$18,516	$32,296	$46,077
Lincoln (new capital):	$57,125	$72,333	$87,541
Salinas (70% Utilization):	$33,223	$46,035	$58,847
Lincoln (70% Utilization):	$72,183	$86,612	$101,041

Table 11. Scenario Results

Each of the figures above represents a range of savings possible based upon the variability in production hours to cut required material. For instance, in Figure 6 the range of savings can be anywhere from $36,303 to $51,115. The figure implies there is no risk associated with implementing this scenario. However, these savings represent reductions based on operations only and do not account for costs associated with moving equipment, training or expenses associated with realizing increased utilization efficiency.

F. Theoretical Perforating/Cutting Machine

This last section of the study takes a look at the potential savings that might be realized if a machine is found that can both perforate solid steel tubing and cut that tubing to the lengths specified by the manufacturing blueprints. A closer examination of Table 5 presented above shows two distinct factors. First, the average amount of perforated material used each month, as determined by this study, is 127,915 feet. Second, the average amount of manufacturing drop (waste) is 20.9%. This means an average of 26,734 feet of the raw material is manufacturing drop (waste) resulting from the cutting operation. Previously, Table 6 provided the cost per foot of both perforated steel tubing and non-perforated steel tubing. These values were determined by taking a weighted monthly average derived from 12 months of inventory. The resulting costs are $0.85/foot for perforated steel tubing raw material and $0.69/foot for solid steel tubing raw material. The differential in price is $0.16. If the manufacturing drop

(waste) figure above can be reduced to zero with a theoretical machine, then the savings that could be achieved can be calculated. If an average of 26,734 feet is manufacturing drop (waste) as a result of the cutting operation then the remainder is good material. This means that on average only 101,180 feet moves to the next step in the manufacturing process. The potential savings that can be achieved equals the sum of the dollar value of material not dropped plus the cost differential between solid steel tubing and perforated steel tubing for the material that moves on through the muffler assembly/manufacturing process and these savings are computed in Table 12 below. Note that the savings reported here should be considered supremum, or maximum values, as we have assumed the drop will be reduced to zero, but some drop would almost certainly still occur, even with the theoretical machine.

Material	Feet	Cost	Extended Value (monthly)
Perforated Material Drop	26,734	$0.85	$22,723.90
Good Perforated Material	101,180	$0.16	$16,188.80
		Total:	$38,912.70

Table 12. Savings with Theoretical Machine

As can be seen above $38,912.70 per month is the maximum average savings that can be achieved with a theoretical machine that translates to maximum average annual savings of $466,952.

In order to achieve these savings the theoretical cutter will need the capacity to replace the shear cutter, the cold saw and the roll cutter. These figures are found in Table 4 above. The average number of cuts per hour required to achieve all the cutting necessary can be used to calculate the capacity requirements for the theoretical cutter. Adding the cutting rates for the three machines equals an average of 8,280 pieces per day. This number translates into a per-hour cutting requirement of 414 cuts, which means .002415 hours per cut or 8.695 seconds per cut cycle time.

This study investigated the Adige® laser cutter as a potential theoretical cutter but discarded it as an option because it did not meet the cycle time necessary to meet the cutting requirements. The laser was only able to perforate at a rate of one second per hole, making the cycle time of some parts as much as ten minutes which is unacceptable to meet Gabilan's needs. An internal study conducted by Gabilan Manufacturing, Inc. commissioned over a year ago looked at a Vemabo® perforating and cutting machine that achieved an average cycle time of about twenty seconds. Two of these machines might be able to capture up to 70% of the savings identified above. An additional study is required to determine if the cycle time of the Vemabo® has been reduced and if all perforated material can be cut with this machine.

G. Recommendations

This section has looked at several options and has developed several recommendations for Gabilan Manufacturing, Inc to adopt. Table 13 summarizes the average cost comparisons between the options discussed throughout this study.

Costs for All Options	Salinas (Baseline)	Lincoln (No New Capital)	Salinas (New Capital)	Lincoln (New Capital)	Salinas (at 70%)	Lincoln (at 70%)
Manpower Cost:	$266,380	$243,746	$234,072	$215,062	$220,409	$200,866
Transportation Cost:	$106,250	$85,221	$106,250	$85,221	$106,250	$85,221
Total Costs:	$372,630	$328,967	$340,322	$300,283	$326,659	$286,087

Table 13. Summary of Average Cost Comparisons for All Options

The first recommendation is to improve the utilization of the current cutting machines operating at Salinas. This will provide the largest savings achievable in the operation as presently configured. Capital investment in a new machine assumes a utilization rate of 70%. Most of the cost savings associated with this investment can be achieved with the current machines. Once this process has been made more efficient the cutting operation can then be moved to Lincoln, Nebraska in order to capture the savings resulting from the difference in labor rates and not shipping any manufacturing drop (waste).

A third and final recommendation is to conduct further investigation into the theoretical machine mentioned above. Investing in this new technology should be made in parallel with the above recommendations and if achieved will result in the largest potential for savings for the organization.

Whether Gabilan chooses to accept any of these recommendations or not, it is important that they begin closely tracking each function conducted within the cutting operation. Several conservative assumptions have been made when developing the models to capture the costs of the operations. More specific and timely data concerning the cutting operation should be collected and that data should replace the assumptions made to develop the risk analysis model.

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VI. DEPARTMENT OF DEFENSE IMPLICATIONS

A. Overview

There are two significant implications of this study to the Department of Defense. First, the value of information and its impact on stocking levels across the supply chain in a monopsony, specifically, from the perspective of a supplier whose entire business is to be the sole source provider of components to a large manufacturer. Second, the value of capital investment and site relocation decisions with regard to capacity utilization and the analysis required in properly identifying causal factors, benefits and drawbacks of such decisions.

B. The Value of Information

The Department of Defense (DoD) and the customer in this study are examples of a monopsony. They represent the sole buyers for a product from its suppliers in a particular field. As such, they have great power to dictate terms to suppliers, usually in the form of lower prices. Suppliers must adapt to these demands or face losing business with the customer.

In the past DoD has kept prices down by cumbersome and complicated contracts which emphasized scrutinizing and challenging the contractor at almost every junction of the contract. This management of the customer/supplier relationship caused many suppliers to go bankrupt or look for alternate industries in which to provide service. Current trends in DoD have emphasized outsourcing and performance based contracts as alternatives to cumbersome close administrative oversight of suppliers. (Murray, 2001) While DoD has been working on partnering with “prime” contractors, to manufacture and deliver finished goods, it can still benefit from the use of forecasting presented in this study. This process improvement would ideally affect the whole supply chain, for instance, by having DoD make more timely, accurate forecasts for the number of new planes they wish to procure, the contractor would be able to better gauge cost, and in turn share information more accurately with their suppliers.

C. The Value of Capital and Location

The Department of Defense is often involved in capital investments in an effort to improve capacity and efficiency in its processes. Additionally, closure and relocation is a very real possibility especially during a Base Realignment and Closure (BRAC) period. In both cases, as with this study, it is imperative to accurately assess the current situation. The DoD conducts these as a matter of course as part of public/private sector competitions called A-76 studies. It would be worthwhile to conduct functional assessments periodically to ensure maximum use of resources. The cutting operation analysis in this report is a minor part of the total business process of the manufacturing company studied. The benefits derived from this are of value to the competitive position of the company. This could serve as a model for the DoD on how to conduct assessments on portions of their operations to obtain efficiencies. The more limited scope of such evaluations does not carry the heavy political implications and pressure typically associated with the larger studies.

With an accurate assessment it is possible to determine the root causes of capacity shortfalls and determine if a capital investment is required to address such deficiencies.

In many cases assets may be found to be underutilized and can be improved by means of proactive management intervention. Capital investment is a good decision, if current processes are efficient and still do not meet capacity requirements. Technology must also be evaluated to ensure it fully meets the desired outcome.

Relocation of an operation is often a sensitive matter where qualitative factors are often more important than quantitative factors. This is especially true for DoD where decisions to close and/or relocate functions can have strong political implications. It is important to accurately compare the costs of conducting business in the current location vice a new location. This allows for transparency in understanding the impact of qualitative decisions.

LIST OF REFERENCES

Aviv, Yossi. "The Effect of Collaborative Forecasting on Supply Chain Performance". *Management Science*. Vol: 47, No: 10. October 2001. Pp. 1326-1343.

Cachon, Ge´rard P. "Managing Supply Chain Demand Variability with Scheduled Ordering Policies". *Management Science*. Vol: 45, No: 6. Pp. 843-856.

Cachon, G.P. and Fischer, M. "Supply Chain Inventory Management and the Value of Shared Information". *Management Science.* Vol: 46, No: 8, August 2000.

Chase, Richard B., Aquilano, Nicholas J., and Jacobs, Robert. Operations Management for Competitive Advantage. Ninth Edition. McGraw-Hill Co., New York 1997. Pp. 290-306, 330-348, 432-465, 551-562.

Evans, J. R. and Olson, D. L. Introduction to Simulation and Risk Analysis. Second Edition. Prentice Hall Co., New Jersey 2002.

F. Chen, J. Ryan, and D. Simchi-Levi. "The Impact of Exponential Smoothing Forecasts on the Bullwhip Effect". *Naval Research Logistics*. Vol: 47, No: 4, June 2000.

Dejonckheere, J., and others. "Measuring and Avoiding the Bullwhip Effect: A Control Theoretic Approach". *European Journal Of Operational Research*. No: 147, 2003.

Donselaar, K., Kopczak, L.R., and Wounters, M. "The use of advance demand information in a project based supply chain". *European Journal of Operational Research*. No: 130, 2001. Pp. 519-538.

Hanfield, R.B., "The Role of Material Management in Developing Time Based Competition". *International Journal of Purchasing and Materials Management*, Winter 1993.

Lee, H.L, So, K.C., and Tang, C.T. "The Value of Information Sharing in a Two-Level Supply Chain". *Management Science.* Vol: 46, No: 5. May 2000.

Li, Lode. "Information Sharing in a Supply Chain with Horizontal Competition". *Management Science.* Vol: 48, No: 9. September 2002. Pp. 1196-1212.

Morgan, R.M. and S.D. Hunt. "The Commitment Trust Theory". *The Journal of Supply Chain Management.* Vol: 38, No: 2. 2002.

Murray, Bill, "DoD Pushes Performance". *Federal Computer Week*, January 8, 2001.

Nahmias, Steven. <u>Production and Operations Analysis.</u> Third Edition. McGraw-Hill Co., New York 1997. Pp. 59-115, 265-328, 369-377, Appendix.

Raedels, A. R., <u>Value-Focused Supply Management-Getting the Most Out of the Supply Chain Function.</u> McGraw-Hill New York 1995.

Saleh, Budiman, Hacker, Marla, and Randhawa, Sabah. “Factors in Capital Decisions Involving Advanced Manufacturing Technologies”. *International Journal of Operations & Production Management*. Vol: 21, No: 10. 2001 Pp. 1265-1288.

Tersine, Richard J. Principles of Inventory and Materials Management. Fourth Edition. Prentice-Hall Inc., New Jersey 1998. Pp. 2-20, 38-70, 204-245.

Xie, Jinxing. “Impact of Forecasting Error on the Performance of Capacitated Multi-Item Production Systems”. *Computers & Industrial Engineering* (accepted). Revised 2001.

Zhao, Xiande, Xie, Jinxing, and Wei, Jerry C. “The Impact of Forecast Errors on Early Order Commitment in a Supply Chain.” *Decision Sciences*. Vol: 33, No: 2. Spring 2002.

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APPENDIX A1

Slide 1

Abstract: Introduction

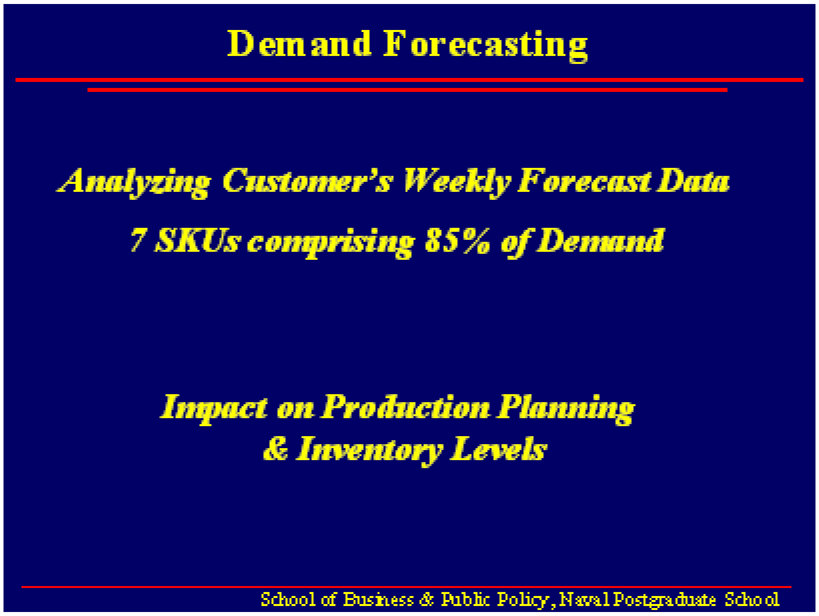
Briefing Script:

The purpose of this presentation is to take advantage of the opportunity to apply the knowledge captured during academic study at the Naval Postgraduate School to assist Gabilan Manufacturing Inc. in improving their supply chain processes. Specifically, two areas of Gabilan operations were focused on, demand forecasting and a cost analysis of the screen and perforated tube-cutting operation. The demand forecasting analysis examined the value of sharing information and its relation to demand, forecasting and the way it impacts the production schedule and suppliers. The second area of analysis, the cutting operation, dealt with capacity, resource allocation, and utilization of the cutting machines. Field studies in the forecasting portion of the analysis were conducted at the main manufacturing facility in Salinas, CA and the warehouse and staging facilities in York, PA. The cutting operation studies were accomplished in

Salinas, CA and the satellite manufacturing facilities in Lincoln, NE as well as the perforated tube supplier located in Lincoln, NE. With the help of Gabilan staff, the researchers were able to develop several models to provide general recommendations on how to improve supply chain management and lower operating costs.

*Note: This brief was given to Gabilan Manufacturing, Inc. executive personnel on 26 November 2003.

Slide 2

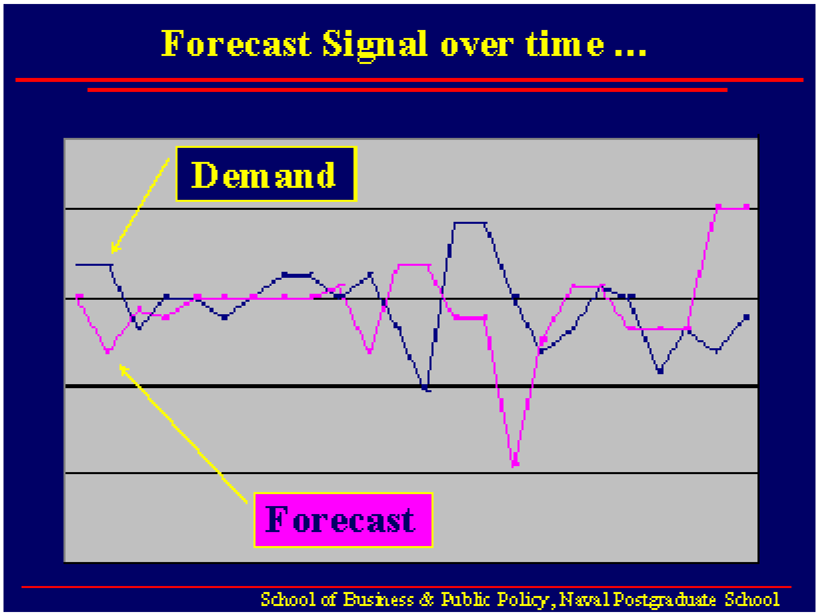


Abstract: Overview of Demand Forecasting

Briefing Script:

The demand forecasting analysis examined seven stock keeping units (SKU's) of different muffler types, which comprises approximately 85% of Gabilan's business with their primary customer. Every week the customer publishes on the Internet a rolling 16 week forecast schedule of their SKU requirements. The SKU's were analyzed for their forecast error and what impact that had on production planning and inventory levels since Gabilan has a long supply chain at both the finished goods and raw materials ends.

Slide 3

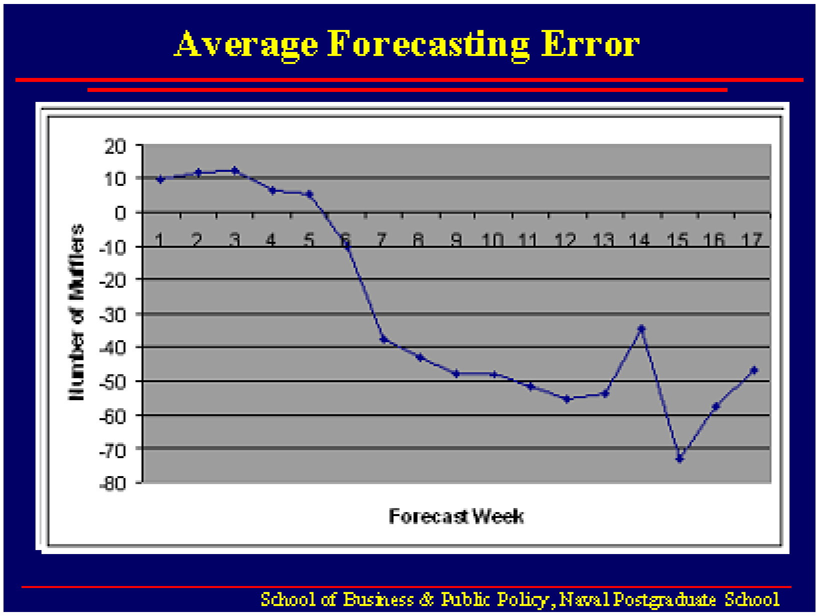


Abstract: Example Using Gabilan Manufacturing, Inc. Forecast Signals Over Time

Briefing Script:

The chart shows an example of one SKU, 65413, with the purple line denoting the rise and fall of mufflers forecasted from Gabilan's customer eight weeks prior to their delivery date over the course of the past year. The blue line depicts the demand actually delivered to the customer eight weeks later. This shows that on average the forecast and demand are off by a significant amount. If Gabilan produced to just the forecasted level of demand, they would consistently be short and would not be able to remain in business for very long. If the forecast were an accurate predictor of the demand, the lines would be superimposed on one another. The eight-week time frame was selected based on Gabilan's placement of material orders and committed material.

Slide 4



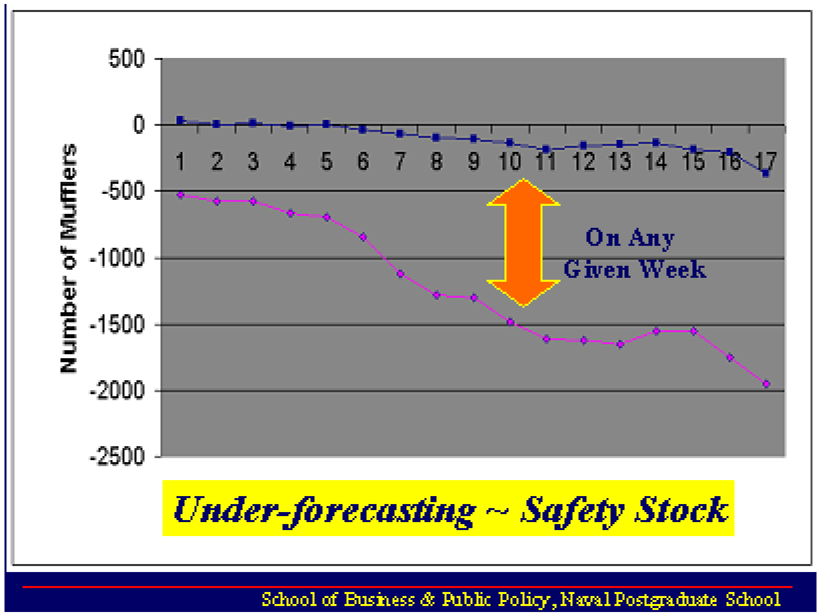
Abstract: Gabilan's Forecast Error for 65413 Muffler

Briefing Script:

The chart depicts the average forecast error in number of mufflers for a particular forecast week. For example, the first week forecast, which represents demand for next week, is actually over forecast on average by ten mufflers. Across the seven SKU's this forecast error follows about the same pattern where about the fifth to sixth week it dips down into an under forecasting average.

Why does Gabilan care about forecasting? Because inventory levels for both raw materials and finished goods are significantly affected. Raw materials must be planned for at the 10 to 8 week period with the finished goods being planned for around the three-week period. The disparity between the two numbers drives up the amount of stock needed in the system, called safety stock, as well as human resources, capacity, and production planning.

Slide 5



Abstract: Gabilan's Forecast Error for 65413 Muffler at Three Standard Deviations

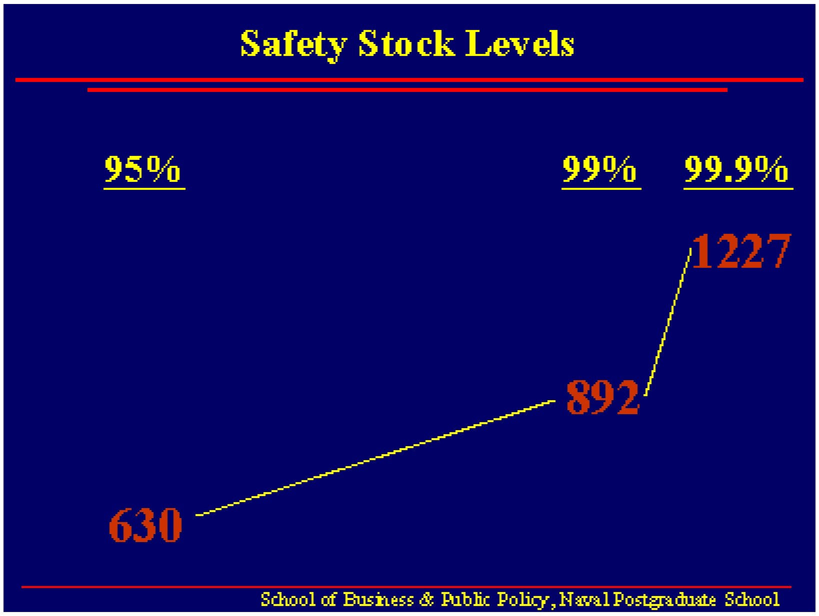
Briefing Script:

This chart is the same as the one before, only changed to a different scale to show how much the average error may be off on a given week. For example, at the eight-week period, the amount of mufflers needed may be under forecasted by as many as 1,200 mufflers. Currently Gabilan knows the forecasts are off and tries to smooth the numbers using their best guess to try to help smooth demand.

The purple line on the chart represents three standard deviations from the average, which takes into account 99% of the possible amount of demand under forecasted by the customer. Another line also exists above the average which represents an over forecasting situation so on any given week, Gabilan may produce as much as 1,200 too many mufflers.

Traditionally, the average has a bias toward the negative, which in industry terms is called under forecasting. This causes companies to hedge against stock outs by carrying extra safety stock and expediting extra shipments. Safety stock is the most important issue and was what the researchers concentrated their efforts on. Safety stock has a standard academic relation to the amount of variability in a system. Larger errors cause more safety stock to be needed. Fall out, which also must be hedged against was accounted for in the model and was calculated using a steady 6% rate.

Slide 6

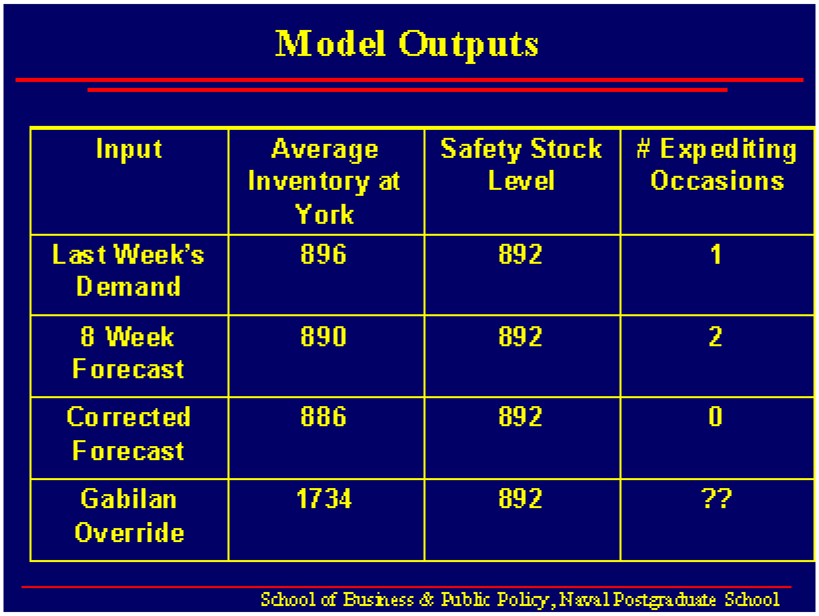


Abstract: Gabilan Manufacturing, Inc. Needed Safety Stock at Different Service Levels

Briefing Script:

The chart shows the theoretical safety stock level calculations required to hedge against the variability that in the forecasting error given to Gabilan by it's customer. At a 95% service level the amount of mufflers required to be on hand is 630 but since Gabilan needs to provide near a 100% service level, at 99% 892 mufflers would need to be stocked to prevent all but a 1% chance at stock out. However, to get to the last 0.9%, Gabilan Manufacturing, Inc. would need to carry almost 400 additional mufflers in inventory.

Slide 7



Model Outputs

Input	Average Inventory at York	Safety Stock Level	# Expediting Occasions
Last Week's Demand	896	892	1
8 Week Forecast	890	892	2
Corrected Forecast	886	892	0
Gabilan Override	1734	892	??

School of Business & Public Policy, Naval Postgraduate School

Abstract: Demand Forecasting Model Output Compared to Current Procedures

Briefing Script:

Several models were developed to assist Gabilan in correcting the forecast error and more accurately predicting future demand. Real demand, forecast data and real inventory numbers were used in the creation of the models and they use data gathered from December 2002 up until model year change over in August 2003 with a 6% fall out rate assumed constant.

The model to focus on, Corrected Forecast, calculates an average inventory safety stock level to be on hand at the warehouse of 886 mufflers. Currently Gabilan has, on average, 1734, as show at the bottom of the chart. The model takes the eight week forecast provided by the customer, corrects that forecast error each week and can therefore theoretically sustain a safety stock level of approximately 50% less than current safety stock levels with no stock outs.

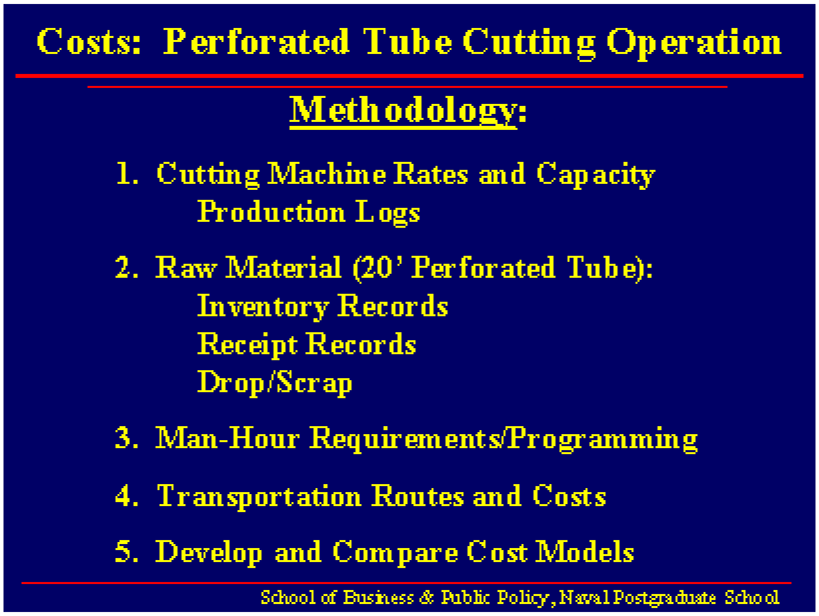
Slide 8

Abstract: Lead-in to Analysis of Perforated and Screen, Steel Tube Cutting Operation

Briefing Script:

One of the initial problems Gabilan identified at the start of the study was a potential capacity problem with the cutting operation and for which they were considering procuring an additional cutting machine to alleviate that problem. From this grew the idea that there may be more than just a capacity problem that warranted study. A cost analysis of the cutting operation was therefore conducted in order to determine the actual costs associated with this operation.

Slide 9

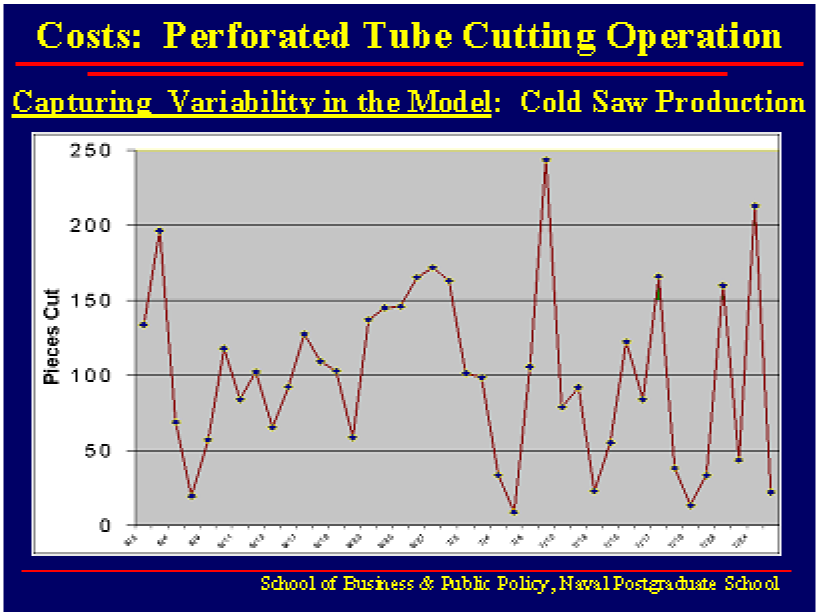


Abstract: Methodology Used in Analysis

Briefing Script:

The Gabilan production manager provided the theoretical cutting rate of each cutting machine and effective cutting rates were determined from the production logs used by the employees. In particular, tubing material was examined by using the inventory records, receipt records and using that data combined with the production from the logs to calculate the manufacturing drop/scrap (waste) material that was produced as a part of the cutting operation. The man-hours programmed for the cutting operation were used to determine the utilization of each cutting machine. The transportation routes and costs associated with those routes were also examined. With this information, cost models were developed in an attempt to determine the costs associated with conducting the cutting operation.

Slide 10

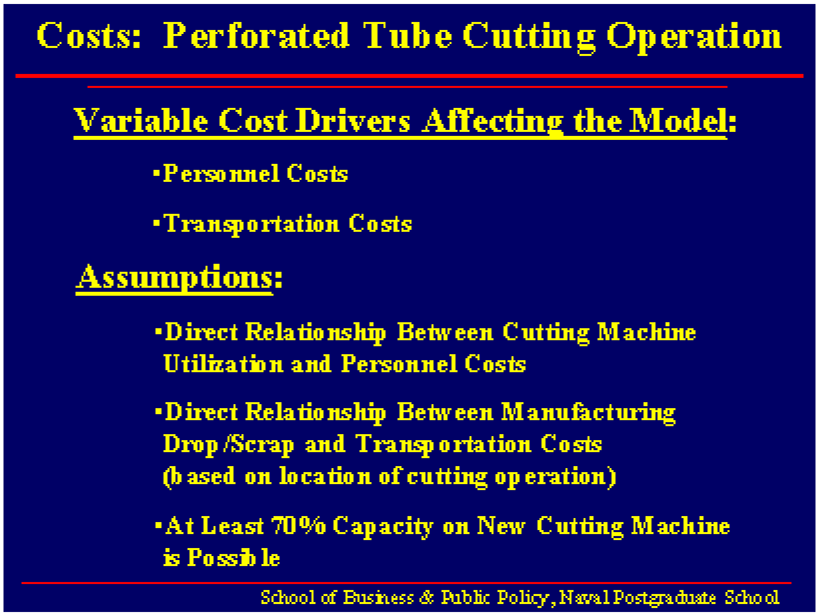


Abstract: Cold Saw Variability in Use During Two Month Period

Briefing Script:

This chart shows the data obtained from examining just one of the cutting machines (cold saw), which shows the average number of pieces cut per hour-per day during a two-month time frame. This shows an unsteady state, which makes fitting a probability distribution very challenging.

Slide 11

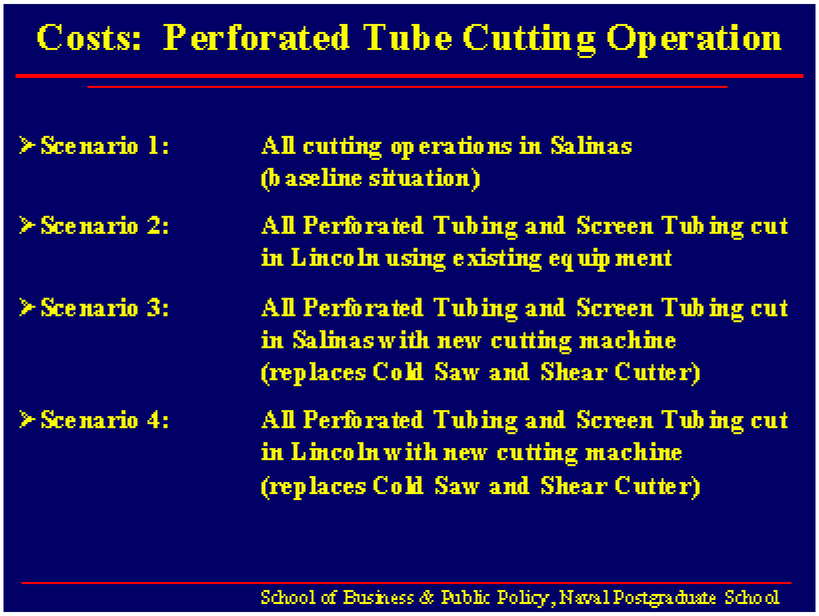


Abstract: Costs Analyzed and Assumptions Made in the Model

Briefing Script:

The two drivers, which determine the costs of doing business, are personnel and transportation costs. In order to develop a cost model, several assumptions were made: a direct relationship exists between the utilization of the cutting machines and the labor required to attain that utilization; a direct relationship exists between manufacturing drop/scrap (waste) and the transportation costs; and if a new Modern-3DL cutter is procured to cut perforated steel tubing, it will be operated at 70% capacity.

Slide 12



Abstract: Scenarios Used in Model

Briefing Script:

Four scenarios were developed to study the costs associated with the cutting operation. Scenario One details the cost of doing operations in Salinas as currently configured and establishes the baseline for the cost comparisons. Scenario Two details the costs of operating the existing screen and perforated tube cutters in Lincoln, NE. Scenario Three involves replacing two perforated tube cutting machines with the Modern-3DL cutter and performing the cutting operation in Salinas, CA. Scenario Four details the costs associated with replacing two perforated tube-cutting machines with the Modern-3DL cutter and performing the screen and perforated tube cutting operation in Lincoln, NE.

Slide 13

Costs: Perforated Tube Cutting Operation

	Capital and Misc. Costs	Operating Costs	Annual Savings
Salinas (baseline)	0	$372,630	0
Lincoln	Move	$328,967	$ 43,663
Salinas (New Cutter)	$196,085	$340,322	$ 32,308
Lincoln (New Cutter)	$196,085 + Move	$ 300,282	$ 72,384

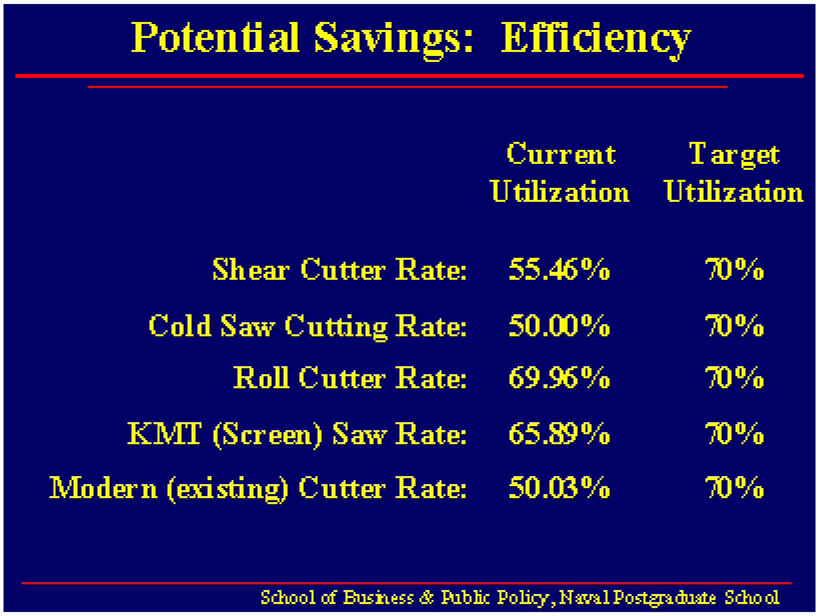
School of Business & Public Policy, Naval Postgraduate School

Abstract: Cost Saving Results From Model of the Four Scenarios

Briefing Script:

This chart provides a breakdown of the results from each of the scenarios. The second column details the cost of the capital and other miscellaneous costs. The miscellaneous costs involve things such as the cost of transportation from Salinas to Lincoln of the current machines, training, installation costs and packaging of cut material for shipment from Lincoln to Salinas. The miscellaneous costs are not specifically addressed in this study. The third column provides the operating costs associated with each scenario. The fourth column breaks down the annual cost savings derived from each one of the scenarios.

Slide 14



Abstract: Analysis of "Capacity" Problem and Potential Savings for Increased Efficiency

Briefing Script:

Since two of the scenarios involved purchasing a new machine and operating it at 70% capacity, a study was conducted to determine the magnitude of cost savings if the utilization rates of the existing machinery were increased to the target rate of 70%. Research based on other manufacturing operations within the similar industries yielded an industry average machine utilization of approximately 85%, so a target utilization rate of 70% seems conservative and fairly reasonable.

Slide 15

Costs: Perforated Tube Cutting Operation

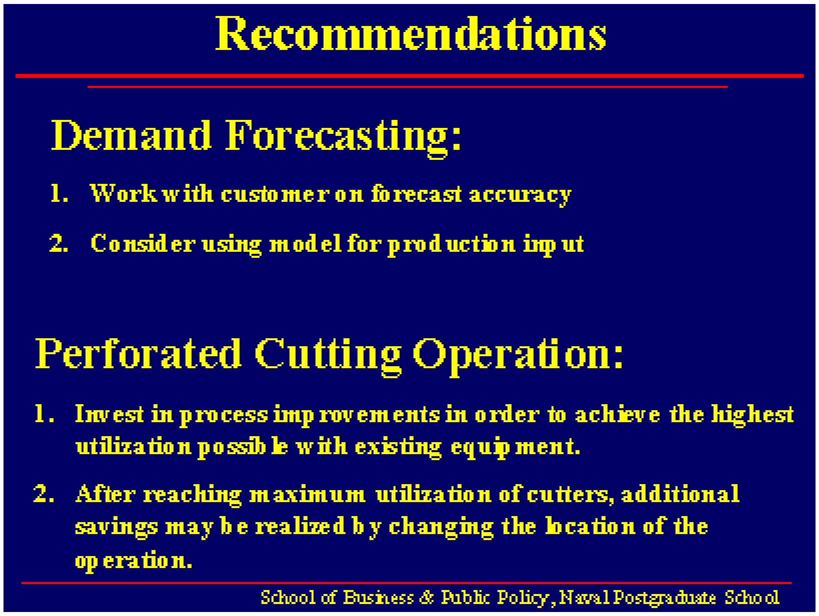
	Capital and Misc. Costs	Annual Operating Costs	Annual Savings
Salinas (baseline)	0	$372,630	0
Lincoln	Move	$328,967	$ 43,663
Salinas (New Cutter)	$196,085	$340,322	$ 32,308
Lincoln (New Cutter)	$196,085 + Move	$ 300,282	$ 72,384
Salinas at 70%	**?**	**$ 326,659**	**$ 45,971**
Lincoln at 70%	**? + Move**	**$ 305,629**	**$ 67,001**

Abstract: Cost Saving Results From Model Using Only Efficiency

Briefing Script:

This chart displays the costs associated with the first four scenarios and the costs associated with increasing existing machine utilization to 70%. While a logical argument can be made that you can reduce costs by using machinery more efficiently, this part of the study puts a dollar value on those costs. Of significant importance is the fact that increased utilization (to a conservative target) can yield greater savings than procuring new equipment.

Slide 16



Abstract: Recommendations

Briefing Script:

Gabilan Manufacturing, Inc. should work closely with its customer to improve forecast accuracy and explain the implications. Consider using the model for a few months in parallel with the existing system to compare how accurate it is. If it provides accurate information, then Gabilan should consider utilizing the model on a more active basis to assist in forecasting operations and realize savings through reductions in inventory safety stock levels.

With respect to the steel-tube cutting operation, efforts should be focused on improving existing operations rather than investing in a new machine. Once efficiency has been improved, further savings may then be realized through relocation of the cutting operation to Lincoln, NE.

APPENDIX B1

65413-00		Forecast Week																
Week	Demand	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	1440																	
2	1440	1440																
3	1440	1440	1440															
4	1440	1440	1440	1440														
5	1440	1500	1500	1500	1380													
6	1440	1440	1500	1500	1500	1440												
7	1440	1440	1440	1500	1500	1500	1500											
8	1500	1500	1440	1500	1500	1500	1500	1500										
9	1680	1500	1500	1500	1500	1500	1500	1500	1500									
10	1680	1620	1500	1500	1500	1500	1200	1200	1200	1260								
11	1320	1320	1320	900	900	1500	900	1440	1440	1440	1440							
12	1500	1500	1500	1500	1500	1500	900	1500	1380	1380	1380	1440						
13	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500					
14	1380	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1440				
15	1500	1500	1500	1500	1500	1500	1320	1500	1500	1500	1500	1500	1500	1500	1500			
16	1620	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1440	1440	1440	1440		
17	1620	1680	1680	1680	1680	1680	1560	1560	1500	1500	1500	1500	1500	1440	1440	1440	1140	
18	1500	1680	1620	1560	1560	1560	1560	1560	1560	1500	1500	1500	1500	1500	1380	1380	1380	1140
19	1620	1620	1620	1620	1440	1440	1320	1200	1200	1200	1200	1140	1140	1500	1140	1020	1020	1020
20	1320	1320	1320	1620	1320	1320	1140	1680	1680	1680	1680	1380	1500	1500	1140	1500	1020	1020
21	960	1680	1680	1680	1320	1800	1740	1860	1680	1620	1680	1680	1680	1440	1440	1500	1440	1020
22	1920	1920	1920	1920	1880	1800	1740	1140	1380	1260	1320	1260	1260	1260	1140	1140	1440	1140
23	1920	1920	1920	1920	1920	1920	1740	1380	1380	1380	1380	1320	1380	1380	1380	1440	1440	1140
24	1500	1500	1500	1500	1500	1500	1420	1380	540	540	540	540	600	540	540	540	1140	1140
25	1200	0	960	960	960	960	540	540	1260	960	1560	1560	1680	1740	1800	1740	1740	1320
26	1560	1560	960	1560	1560	1560	1560	1560	1560	1560	1560	1560	1560	1680	1740	1860	1500	1500
27	1560	1560	1560	1560	1560	1560	1560	1560	1560	1560	1560	1560	1440	1560	1560	1620	1500	1500
28	1500	1500	1500	1500	1560	1320	1320	1320	1320	1440	1440	1320	1440	1380	1380	1080	1080	900
29	1080	1320	1320	1320	1320	1320	1320	1320	1320	1320	1380	1380	1320	1380	1320	1320	1320	960
30	1320	1440	1440	1440	1440	1440	1320	1320	1320	1320	1320	1320	1320	1320	1320	1320	1260	1140
31	1200	1320	1320	1320	1320	1320	1980	1320	2520	2520	2520	2520	1260	1260	1380	1320	1320	1080
32	1380	1380	1380	1380	1380	1380	1380	1020	2520	960	960	960	960	1080	1080	1080	1320	960
33	1080	1080	1080	1080	1080	1080	1080	840	0	960	0	0	0	0	1380	1380	1380	960
34	1080	1320	1320	1320	1320	1320	1320	1380	1080	1140	0	1200	1200	1200	1200	1380	1380	1080
35	1620	1320	1380	1380	1380	1380	1320	1380	1380	1380	1440	1200	1380	1380	1380	1380	1080	1080
36	1560	1560	1380	1500	1500	1500	1500	1500	1500	1500	1500	1500	1380	1500	1500	1500	1500	1080
37	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1140	1140	1140	1140
38	1620	1560	1560	1560	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1140	1140	1140	1140
39	1620	1620	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1440	1440	1440	1140	1140	1140
40	1620	1620	1620	1500	1500	1500	1500	1560	1560	1560	1560	1500	1560	1620	1620	1620	1140	1140
41	1620	1620	1620	1620	1290	1290	1290	1560	1140	1140	1140	1140	1140	1140	2520	2520	1140	1140
42	1500	1740	1740	1740	1620	1290	1290	1290	1140	1140	1140	1140	1140	1140	1140	1020	1020	1140
43	1320	1320	1320	1320	1320	1620	1290	1290	1290	1140	1140	1140	1140	1140	1140	1140	0	0
44	1620	1620	1620	1620	1620	1620	1620	1290	1290	1290	1140	1140	1140	1140	1140	1140	1140	1800
45	1020	1020	1020	1020	1620	1620	1620	720	720	720	720	1140	1140	1140	1140	1140	1140	1140
46	1320	1320	1320	1320	1320	1620	1620	1020	1120	1120	1120	1120	1140	1140	1140	1140	1140	1140
47	1320	1680	1620	1620	1620	1620	1620	1620	1380	1680	1120	1120	1120	1140	1620	1620	1620	1320
48	1680	1680	1680	1620	1620	1620	1620	1560	1680	1620	1620	1120	1120	1120	1620	1620	1620	1620
49	660	660	660	660	660	660	660	540	60	0	0	0	0	0	0	0	1620	1620
50	1800	1680	1680	1680	1680	1680	1680	1620	1620	1620	1020	900	900	900	960	960	960	1620
51	1800	1800	1680	1680	1680	1680	1740	1680	1620	1620	1560	1620	1620	1560	1560	1260	1260	1260
52	1800	1800	1800	1680	1680	1680	1680	1680	1680	1680	1680	1680	1620	1560	1560	1560	1260	1260
53	1440	1800	1800	1800	1680	1680	1680	1560	1620	1560	1560	1560	1620	1680	1680	1620	1620	1260
54	1800	1800	1800	1800	1800	1620	1620	1620	1620	1560	1620	1560	1620	1680	1680	1680	1620	1260
55	1440	1800	1800	1740	1740	1740	1560	1560	1560	1560	1560	1560	1620	1620	1680	1620	1740	1260
56	1440	1800	1800	1800	1800	1800	1800	1560	1560	1560	1620	1620	1620	1620	1680	1740	1740	1320
57	1800	1800	1800	1800	1800	1800	1800	1920	1920	1920	1920	1920	1920	1920	1800	1740	1740	1380
58	1500	1800	1800	1800	1800	1800	1800	1920	1860	1920	1920	1920	1920	1920	1860	1800	1680	1380
59	1860	1870	1810	1800	1800	1800	1800	1920	1860	1920	1860	1860	1860	1860	1860	1860	1800	1380

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APPENDIX B2

Error Statistic Calculations

Mean Absolute Deviation (MAD), indicates the mean absolute error, or the deviation, of the forecast. This measure obviously does not consider whether the error is positive or negative and is given by,

$$\mathbf{MAD = \sum \mid D_i - F_i \mid / n}$$

Mean Squared Error (MSE), indicates the average of the squared errors. MSE penalizes the forecast more heavily for making larger errors than for smaller ones and is given by,

$$\mathbf{MSE = \sum (D_i - F_i)^2 / n}$$

Percent Error (% Error), indicates the error as a percentage of realized demand for time, i, and is for those who would rather view the forecast error as a percentage. It is given by,

$$\mathbf{\%\ Error = \mid D_i - F_i \mid / D_i}$$

Mean Absolute Percent Error (MAPE), indicates the average error term in percentage across the entire range of data. A smaller MAPE is ideal and is given by,

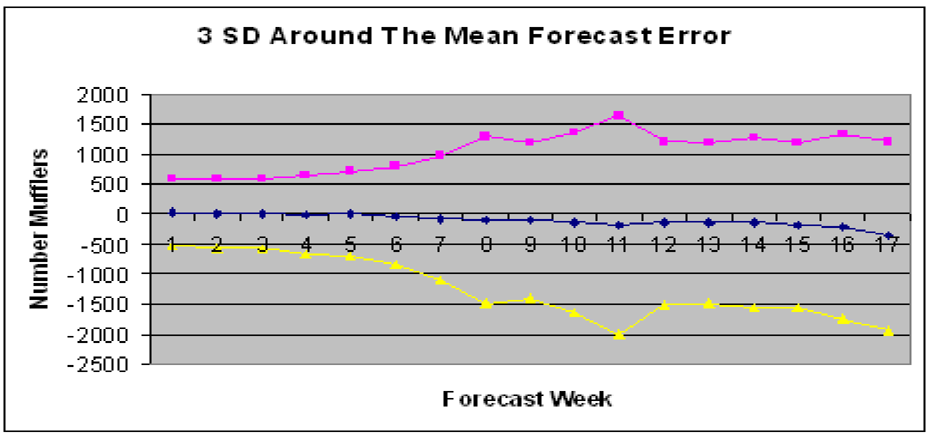
$$\mathbf{MAPE = (100 \sum \mid D_i - F_i \mid / D_i) / n}$$

Tracking Signal (TS), indicates the ratio of cumulative error and MAD, tracking how the average forecast error is tending. It is given by,

$$\mathbf{TS = \sum (D_i - F_i) / MAD}$$

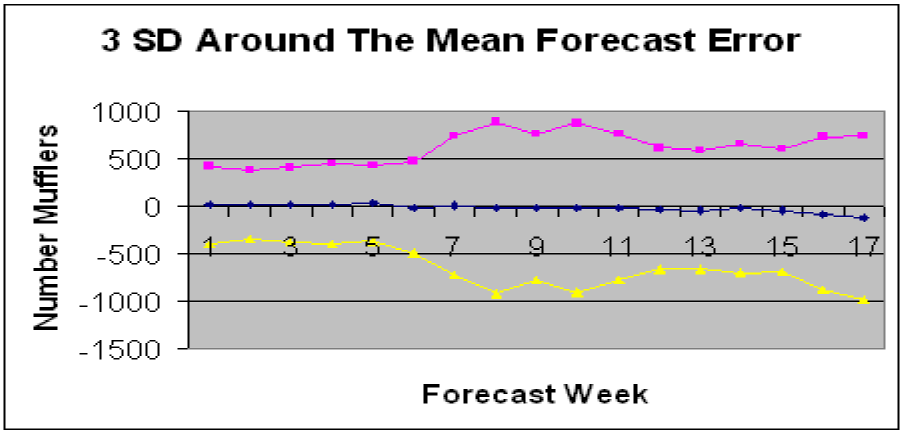
65413-00 Summary Statistics

Wk	MFE	MAD	MSE or Variance	RMSE	% Error	MAPE	TS	MFE	Plus 3 SD's	Minus 3 SD's
1	29.95	102.18	34365.72	185.38	0.03	0.07	23.16	29.95	586	-526
2	4.00	116.46	37585.56	193.87	0.00	0.08	2.68	4.00	586	-578
3	6.96	132.57	38384.36	195.92	0.03	0.09	4.04	6.96	595	-581
4	-8.99	155.20	48663.01	220.60	0.03	0.10	-4.40	-8.99	653	-671
5	6.21	162.27	55044.91	234.62	0.00	0.11	2.87	6.21	710	-698
6	-33.85	199.50	75667.88	275.08	0.00	0.14	-12.56	-33.85	791	-859
7	-72.85	241.10	120087.56	346.54	0.02	0.16	-22.06	-72.85	967	-1112
8	-95.89	318.14	215699.58	464.43	0.01	0.22	-21.70	-95.89	1297	-1489
9	-108.93	292.99	187553.49	433.07	0.02	0.20	-26.40	-108.93	1190	-1408
10	-133.97	337.80	249432.83	499.43	0.02	0.24	-27.76	-133.97	1364	-1632
11	-185.65	371.97	367071.71	605.86	0.07	0.24	-34.44	-185.65	1632	-2003
12	-153.07	317.01	204043.72	451.71	0.02	0.22	-32.83	-153.07	1202	-1508
13	-148.51	315.01	200198.63	447.44	0.02	0.22	-31.59	-148.51	1194	-1491
14	-141.00	348.82	221145.15	470.26	0.52	0.23	-26.68	-141.00	1270	-1552
15	-186.82	365.92	208141.62	456.23	0.61	0.24	-33.18	-186.82	1182	-1555
16	-209.42	400.48	265304.27	515.08	0.61	0.27	-33.47	-209.42	1336	-1755
17	-365.13	450.62	278263.38	527.51	0.58	0.28	-51.05	-365.13	1217	-1948



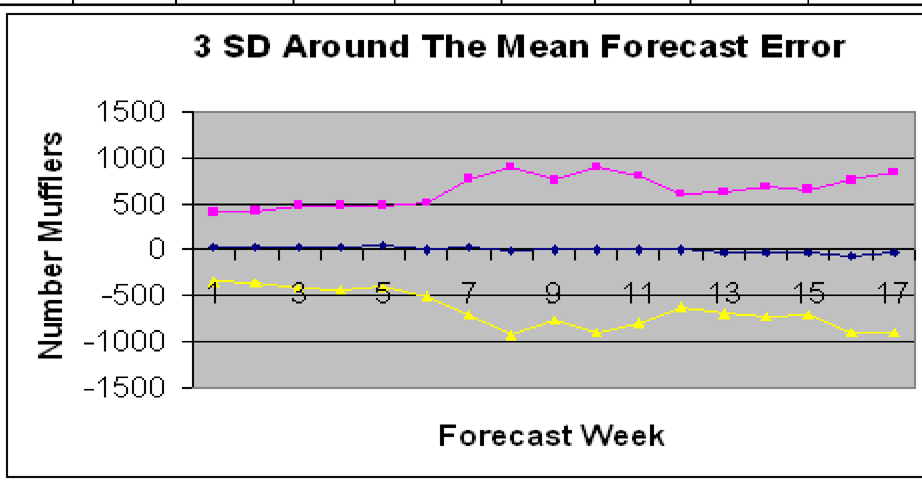
65538-95A SUMMARY STATISTICS

Wk	MFE	MAD	MSE or Variance	RMSE	% Error	MAPE	TS	MFE	Plus 3 SD's	Minus 3 SD's
1	16.28	51.72	18427.14	135.75	0.04	0.06	24.86	16.28	423.52	-390.96
2	23.35	60.73	14202.04	119.17	0.00	0.07	29.98	23.35	380.86	-334.17
3	17.31	72.04	17359.34	131.75	0.04	0.08	18.50	17.31	412.58	-377.95
4	25.78	78.80	19262.46	138.79	0.04	0.09	24.86	25.78	442.14	-390.59
5	32.13	72.72	17891.73	133.76	0.03	0.09	33.14	32.13	433.41	-369.15
6	-12.15	89.85	26474.93	162.71	0.03	0.11	-10.01	-12.15	475.98	-500.28
7	11.74	127.16	59933.30	244.81	0.00	0.15	6.74	11.74	746.18	-722.70
8	-16.93	168.93	90356.65	300.59	0.01	0.19	-7.22	-16.93	884.85	-918.71
9	-15.85	150.44	65374.83	255.69	0.02	0.17	-7.48	-15.85	751.21	-782.90
10	-14.97	166.63	87965.69	296.59	0.02	0.19	-6.29	-14.97	874.80	-904.74
11	-15.68	150.20	65550.38	256.03	0.02	0.18	-7.20	-15.68	752.40	-783.77
12	-25.63	127.07	44466.84	210.87	0.02	0.15	-13.72	-25.63	606.98	-658.25
13	-39.33	131.87	43237.18	207.94	0.06	0.15	-19.98	-39.33	584.48	-663.13
14	-23.76	147.91	50368.67	224.43	0.08	0.16	-10.60	-23.76	649.53	-697.05
15	-42.97	145.80	45945.62	214.35	0.08	0.16	-19.16	-42.97	600.08	-686.02
16	-76.84	185.06	72154.06	268.62	0.06	0.22	-26.57	-76.84	729.00	-882.69
17	-120.05	213.03	82718.62	287.61	0.03	0.23	-35.50	-120.05	742.78	-982.87



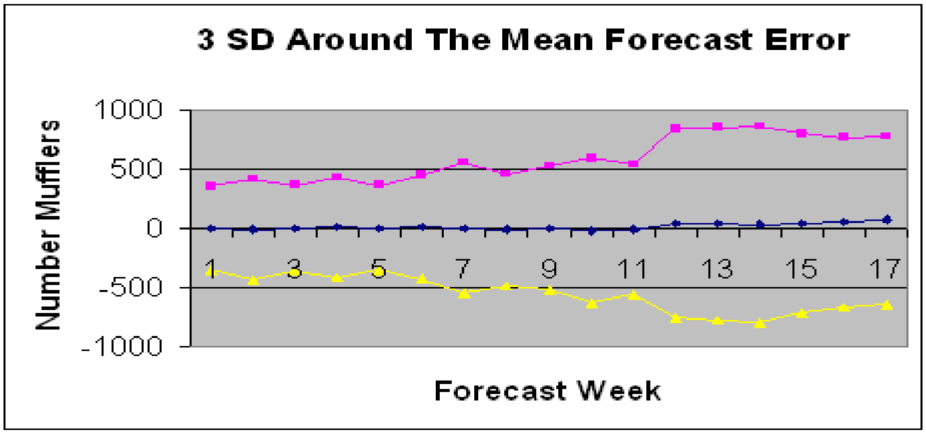
65539-95A SUMMARY STATISTICS

Wk	MFE	MAD	MSE or Variance	RMSE	% Error	MAPE	TS	MFE	Plus 3 SD's	Minus 3 SD's
1	30.80	58.09	16139.28	127.04	0.04	0.08	41.88	30.80	411.92	-350.32
2	31.14	68.12	16955.27	130.21	0.00	0.08	35.66	31.14	421.78	-359.50
3	26.55	85.27	23054.23	151.84	0.04	0.10	23.97	26.55	482.05	-428.96
4	23.05	91.89	23890.63	154.57	0.04	0.11	19.07	23.05	486.75	-440.65
5	38.45	83.81	21605.49	146.99	0.05	0.10	34.41	38.45	479.42	-402.51
6	1.00	97.41	29118.65	170.64	0.00	0.12	0.76	1.00	512.93	-510.93
7	27.37	134.90	60403.29	245.77	0.00	0.16	14.81	27.37	764.68	-709.94
8	-10.22	172.69	93944.00	306.50	0.01	0.20	-4.26	-10.22	909.29	-929.73
9	-5.24	152.31	64889.46	254.73	0.02	0.18	-2.44	-5.24	758.96	-769.44
10	-0.79	171.07	90521.47	300.87	0.02	0.20	-0.32	-0.79	901.82	-903.39
11	-4.61	168.14	71473.54	267.35	0.02	0.20	-1.89	-4.61	797.43	-806.64
12	-5.44	124.59	41863.91	204.61	0.02	0.16	-2.97	-5.44	608.38	-619.26
13	-32.22	140.79	48844.70	221.01	0.06	0.17	-15.33	-32.22	630.80	-695.25
14	-25.35	152.83	54913.68	234.34	0.08	0.17	-10.95	-25.35	677.66	-728.36
15	-33.40	153.43	51665.00	227.30	0.08	0.18	-14.15	-33.40	648.50	-715.30
16	-74.84	191.78	77181.31	277.82	0.06	0.23	-24.98	-74.84	758.60	-908.29
17	-113.89	218.27	85152.65	291.81	0.03	0.24	63.00	-32.87	842.56	-908.30



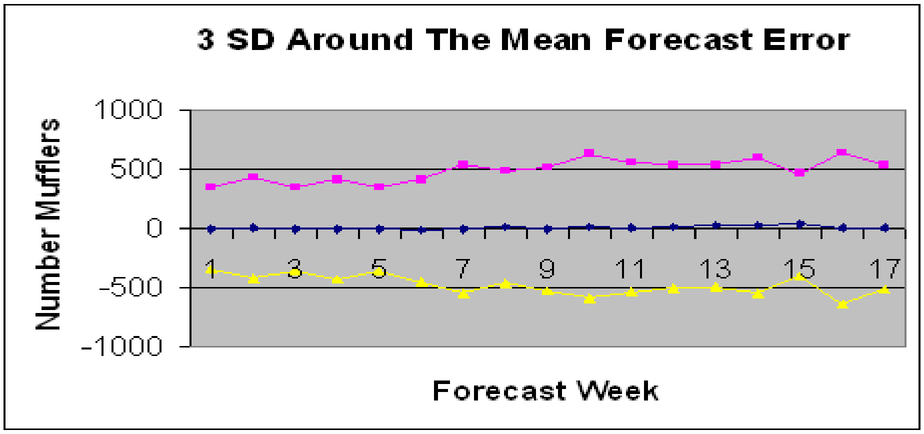
65605-97 SUMMARY STATISTICS

Wk	MFE	MAD	MSE or Variance	RMSE	% Error	MAPE	TS	MFE	Plus 3 SD's	Minus 3 SD's
1	-1.37	64.46	13840.89	117.65	0.01	0.08	-1.68	-1.37	351.57	-354.31
2	-8.01	73.94	20444.04	142.98	0.02	0.10	-8.45	-8.01	420.94	-436.96
3	3.12	67.04	14640.18	121.00	0.01	0.09	3.58	3.12	366.11	-359.87
4	6.92	75.03	20073.03	141.68	0.01	0.11	7.01	6.92	431.96	-418.12
5	4.01	70.36	14421.56	120.09	0.01	0.09	4.28	4.01	364.28	-356.26
6	14.93	85.36	21283.80	145.89	0.01	0.11	12.94	14.93	452.60	-422.74
7	0.74	107.84	33336.55	182.58	0.01	0.15	0.50	0.74	548.49	-547.01
8	-13.17	99.81	25139.58	158.55	0.01	0.14	-9.50	-13.17	462.50	-488.83
9	4.83	104.24	30537.31	174.75	0.01	0.15	3.29	4.83	529.08	-519.42
10	-22.46	114.54	42231.80	205.50	0.01	0.16	-13.72	-22.46	594.05	-638.97
11	-8.43	112.96	33877.25	184.06	0.01	0.17	-5.15	-8.43	543.74	-560.61
12	45.31	195.60	71539.51	267.47	0.33	0.29	15.75	45.31	847.71	-757.10
13	40.45	201.46	74403.97	272.77	0.33	0.29	13.45	40.45	858.76	-777.86
14	35.17	198.77	77235.32	277.91	0.33	0.29	11.68	35.17	868.90	-798.57
15	39.94	181.14	64282.28	253.54	0.33	0.26	14.33	39.94	800.56	-720.68
16	54.66	173.47	57381.28	239.54	0.33	0.25	20.17	54.66	773.29	-663.98
17	68.49	169.76	55909.35	236.45	0.33	0.24	25.42	68.49	777.85	-640.86



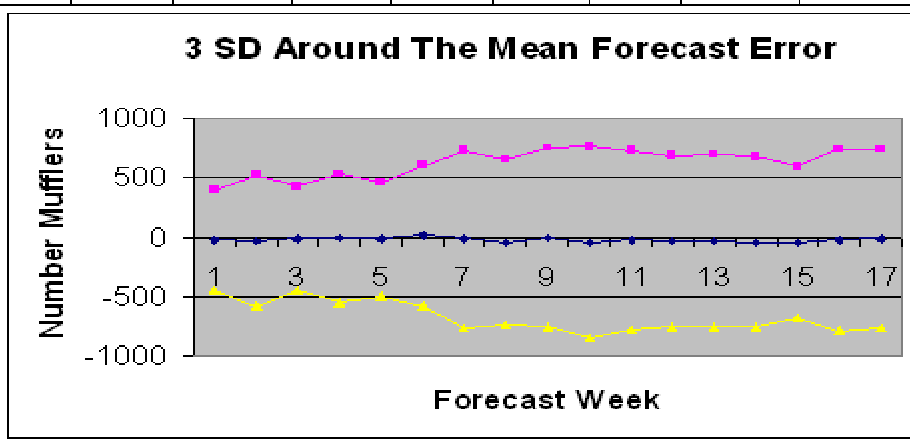
65613-97 SUMMARY STATISTICS

Wk	MFE	MAD	MSE or Variance	RMSE	% Error	MAPE	TS	MFE	Plus 3 SD's	Minus 3 SD's
1	-0.38	62.68	13594.20	116.59	0.01	0.08	-0.48	-0.38	349.40	-350.16
2	6.23	72.15	20196.33	142.11	0.02	0.10	6.74	6.23	432.57	-420.11
3	-4.92	65.23	14389.26	119.96	0.01	0.08	-5.81	-4.92	354.94	-364.79
4	-8.75	73.20	19818.80	140.78	0.01	0.11	-9.09	-8.75	413.59	-431.09
5	-5.87	70.13	14390.05	119.96	0.01	0.09	-6.27	-5.87	354.01	-365.74
6	-16.81	83.49	21015.19	144.97	0.01	0.11	-14.90	-16.81	418.09	-451.71
7	-2.64	105.93	33064.26	181.84	0.01	0.15	-1.82	-2.64	542.86	-548.15
8	11.24	97.88	24863.51	157.68	0.01	0.14	8.27	11.24	484.28	-461.81
9	-6.69	102.28	30257.35	173.95	0.01	0.15	-4.71	-6.69	515.15	-528.53
10	20.47	112.56	41951.81	204.82	0.01	0.16	12.73	20.47	634.93	-593.99
11	6.42	111.09	33617.38	183.35	0.01	0.17	3.99	6.42	556.47	-543.63
12	16.21	108.09	30253.06	173.93	0.01	0.16	10.20	16.21	538.01	-505.60
13	21.93	106.64	30056.34	173.37	0.06	0.15	13.78	21.93	542.03	-498.18
14	27.23	110.62	36904.83	192.11	0.01	0.16	16.24	27.23	603.55	-549.09
15	33.83	93.40	20887.25	144.52	0.02	0.13	23.54	33.83	467.40	-399.74
16	3.19	111.56	46279.78	215.13	0.01	0.18	1.83	3.19	648.57	-642.19
17	9.64	105.83	30733.25	175.31	0.02	0.14	5.74	9.64	535.56	-516.29



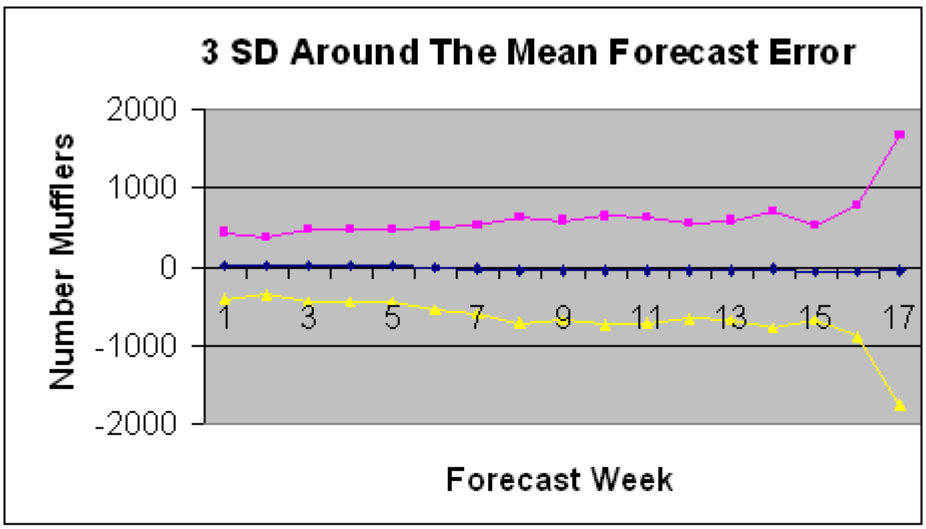
65747-94 SUMMARY STATISTICS

Wk	MFE	MAD	MSE or Variance	RMSE	% Error	MAPE	TS	MFE	Plus 3 SD's	Minus 3 SD's
1	-22.97	100.22	19920.72	141.14	0.04	0.10	-18.11	-22.97	400.45	-446.40
2	-34.92	120.00	34054.87	184.54	0.02	0.12	-22.70	-34.92	518.70	-588.54
3	-10.60	110.39	21417.87	146.35	0.04	0.11	-7.39	-10.60	428.45	-449.64
4	-9.89	125.11	33037.37	181.76	0.04	0.14	-6.01	-9.89	535.39	-555.18
5	-18.27	120.24	26081.65	161.50	0.05	0.12	-11.39	-18.27	466.23	-502.76
6	11.15	137.69	39899.47	199.75	0.05	0.14	5.99	11.15	610.39	-588.10
7	-19.66	165.11	62526.10	250.05	0.05	0.17	-8.69	-19.66	730.50	-769.81
8	-42.78	156.67	53771.44	231.89	0.04	0.16	-19.66	-42.78	652.88	-738.44
9	-7.54	155.23	63418.49	251.83	0.05	0.16	-3.45	-7.54	747.96	-763.03
10	-44.51	168.00	73048.77	270.28	0.05	0.17	-18.55	-44.51	766.31	-855.34
11	-23.86	168.09	64049.48	253.08	0.05	0.18	-9.79	-23.86	735.38	-783.10
12	-38.13	156.28	58334.49	241.53	0.05	0.15	-16.59	-38.13	686.44	-762.71
13	-35.21	160.55	59140.97	243.19	0.07	0.16	-14.69	-35.21	694.36	-764.78
14	-41.52	161.03	58331.61	241.52	0.09	0.16	-17.02	-41.52	683.04	-766.07
15	-49.14	146.37	45949.26	214.36	0.09	0.14	-21.82	-49.14	593.93	-692.21
16	-27.80	162.86	65722.05	256.36	0.09	0.19	-10.92	-27.80	741.29	-796.89
17	-15.75	167.81	63708.79	252.41	0.09	0.16	-5.91	-15.75	741.47	-772.96



65890-00 SUMMARY STATISTICS

Wk	MFE	MAD	MSE or Variance	RMSE	% Error	MAPE	TS	MFE	Plus 3 SD's	Minus 3 SD's
1	9.76	65.71	19510.09	139.68	0.08	0.10	11.73	9.76	428.80	-409.28
2	11.51	67.95	14626.15	120.94	0.00	0.10	13.22	11.51	374.33	-351.30
3	12.27	90.90	22616.77	150.39	0.08	0.14	10.40	12.27	463.44	-438.89
4	6.45	94.76	23052.13	151.83	0.08	0.15	5.17	6.45	461.94	-449.04
5	5.27	92.12	22656.41	150.52	0.00	0.14	4.29	5.27	456.83	-446.29
6	-10.50	110.88	30119.61	173.55	0.00	0.18	-7.01	-10.50	510.15	-531.15
7	-37.66	123.19	35514.70	188.45	0.25	0.19	-22.31	-37.66	527.70	-603.02
8	-42.88	147.65	48377.13	219.95	0.26	0.23	-20.91	-42.88	616.97	-702.72
9	-47.66	142.99	43114.56	207.64	0.26	0.23	-23.67	-47.66	575.26	-670.58
10	-48.03	140.89	52953.06	230.12	0.31	0.22	-23.86	-48.03	642.32	-738.37
11	-51.62	149.30	49591.65	222.69	0.31	0.25	-23.86	-51.62	616.45	-719.70
12	-55.04	132.63	38768.60	196.90	0.31	0.21	-28.22	-55.04	535.65	-645.74
13	-53.60	137.57	43541.63	208.67	0.25	0.23	-26.10	-53.60	572.40	-679.60
14	-34.23	155.89	59299.17	243.51	0.50	0.25	-14.49	-34.23	696.32	-764.77
15	-73.18	149.65	39773.86	199.43	0.50	0.24	-31.79	-73.18	525.12	-671.49
16	-57.27	178.02	75495.89	274.77	0.50	0.31	-20.59	-57.27	767.03	-881.56
17	-46.56	269.63	324822.43	569.93	0.42	0.39	-10.88	-46.56	1663.24	-1756.35



APPENDIX B3

Model 1: 65413-00

Simulation using Previous Demand Data + 6% Chroming Fall-out										
				York		York	SE			
	Salinas	X-it	X-it	Avail	Cust	Ending	Signal	SE		SD
Time	Production	Ne	York	Inv	Demand	Inv	Error	Squared	MSE	RMSE
					1800					
1	1915	1700	1700	2608	1800	808				
2	1915	1915	1598	2406	1800	606				
3	1915	1915	1800	2406	1800	606	0	0	0	0
4	1915	1915	1800	2406	1800	606	0	0	0	0
5	1915	1915	1800	2406	1800	606	0	0	0	0
6	1915	1915	1800	2406	1440	966	360	129600	32400	180
7	1532	1915	1800	2766	1800	966	0	0	25920	160.9969
8	1915	1532	1800	2766	1440	1326	360	129600	43200	207.8461
9	1532	1915	1440	2766	1440	1326	0	0	37029	192.4281
10	1532	1532	1800	3126	1800	1326	0	0	32400	180
11	1915	1532	1440	2766	1500	1266	-60	3600	29200	170.8801
12	1596	1915	1440	2706	1860	846	-420	176400	43920	209.571
13	1979	1596	1800	2646	1920	726	-120	14400	41236	203.0674
14	2043	1979	1500	2226	1860	366	-360	129600	48600	220.4541
15	1979	2043	1860	2226	1628	598	232	53824	49002	221.3636
16	1732	1979	1920	2518	1638	880	282	79524	51182	226.2344
17	1743	1732	1860	2740	1288	1452	572	327184	69582	263.7843
18	1370	1743	1628	3080	1610	1470	18	324	65254	255.4476
19	1713	1370	1638	3108	1654	1454	-16	256	61430	247.851
20	1760	1713	1288	2742	1690	1052	-402	161604	66995	258.8346
21	1798	1760	1610	2662	1662	1000	-52	2704	63612	252.2134
22	1768	1798	1654	2654	1646	1008	8	64	60434	245.8337
23	1751	1768	1690	2698	1426	1272	264	69696	60875	246.7291
24	1517	1751	1662	2934	1800	1134	-138	19044	58974	242.8453
25	1915	1517	1646	2780	1806	974	-160	25600	57523	239.8391
26	1921	1915	1426	2400	1804	596	-378	142884	61080	247.1427
27	1919	1921	1800	2396	1952	444	-152	23104	59560	244.0502
28	2077	1919	1806	2250	1504	746	302	91204	60778	246.531
29	1600	2077	1804	2550	1736	814	68	4624	58698	242.2762
30	1847	1600	1952	2766	1948	818	4	16	56602	237.9117
31	2072	1847	1504	2322	2014	308	-510	260100	63619	252.2284
32	2143	2072	1736	2044	2127	-83	-391	152881	66595	258.0592
33	2263	2143	1948	1865	2123	-258	-175	30625	65434	255.8012
					Average	851	-28			

Model 1: 65538-95A

Simulation using Previous Demand Data + 6% Chroming Fall-out										
				York		York	SE			
	Salinas	X-it	X-it	Avail	Cust	Ending	Signal	SE		SD
Time	Production	Ne	York	Inv	Demand	Inv	Error	Squared	MSE	RMSE
					940					
1	1000	945	945	2402	940	1462				
2	1000	1000	888	2350	940	1410				
3	1000	1000	940	2350	1000	1350	-60	3600	3600.00	60.00
4	1064	1000	940	2290	989	1301	-49	2401	3000.50	54.78
5	1052	1064	940	2241	1040	1201	-100	10000	5333.67	73.03
6	1106	1052	1000	2201	1100	1101	-100	10000	6500.25	80.62
7	1170	1106	989	2090	762	1328	227	51529	15506.00	124.52
8	811	1170	1040	2368	1158	1210	-118	13924	15242.33	123.46
9	1232	811	1100	2310	679	1631	421	177241	38385.00	195.92
10	722	1232	762	2393	1052	1341	-290	84100	44099.38	210.00
11	1119	722	1158	2499	1167	1332	-9	81	39208.44	198.01
12	1241	1119	679	2011	1077	934	-398	158404	51128.00	226.12
13	1146	1241	1052	1986	1066	920	-14	196	46497.82	215.63
14	1134	1146	1167	2087	1251	836	-84	7056	43211.00	207.87
15	1331	1134	1077	1913	1161	752	-84	7056	40429.85	201.07
16	1235	1331	1066	1818	1164	654	-98	9604	38228.00	195.52
17	1238	1235	1251	1905	923	982	328	107584	42851.73	207.01
18	982	1238	1161	2143	1154	989	7	49	40176.56	200.44
19	1228	982	1164	2153	1143	1010	21	441	37839.18	194.52
20	1216	1228	923	1933	1096	837	-173	29929	37399.72	193.39
21	1166	1216	1154	1991	1087	904	67	4489	35667.58	188.86
22	1156	1166	1143	2047	1082	965	61	3721	34070.25	184.58
23	1151	1156	1096	2061	862	1199	234	54756	35055.29	187.23
24	917	1151	1087	2286	1100	1186	-13	169	33469.55	182.95
25	1170	917	1082	2268	1100	1168	-18	324	32028.43	178.96
26	1170	1170	862	2030	1100	930	-238	56644	33054.08	181.81
27	1170	1170	1100	2030	1117	913	-17	289	31743.48	178.17
28	1188	1170	1100	2013	906	1107	194	37636	31970.12	178.80
29	964	1188	1100	2207	1084	1123	16	256	30795.52	175.49
30	1153	964	1117	2240	1129	1111	-12	144	29700.82	172.34
31	1201	1153	906	2017	1149	868	-243	59049	30712.83	175.25
32	1222	1201	1084	1952	1151	801	-67	4489	29838.70	172.74
33	1224	1222	1129	1930	1107	823	22	484	28891.77	169.98
					Average	1058.6	-19			

Model 1: 65890-00

Simulation using Previous Demand Data + 6% Chroming Fall-out as Input										
				York		York	SE			
	Salinas	X-it	X-it	Avail	Cust	Ending	Signal	SE		SD
Time	Production	Ne	York	Inv	Demand	Inv	Error	Squared	MSE	RMSE
					664					
1	706	706	706	2,183	664	1,519				
2	706	706	664	2,183	664	1,519				
3	706	706	664	2,183	544	1,639	120	14400	14400	120
4	579	706	664	2,303	695	1,608	-31	961	7680.5	87.63846
5	739	579	664	2,272	680	1,592	-16	256	5205.667	72.15031
6	723	739	544	2,136	782	1,354	-238	56644	18065.25	134.407
7	832	723	695	2,049	756	1,293	-61	3721	15196.4	123.2737
8	804	832	680	1,973	782	1,191	-102	10404	14397.67	119.9903
9	832	804	782	1,973	604	1,369	178	31684	16867.14	129.8736
10	643	832	756	2,125	600	1,525	156	24336	17800.75	133.4195
11	638	643	782	2,307	592	1,715	190	36100	19834	140.8332
12	630	638	604	2,319	662	1,657	-58	3364	18187	134.8592
13	704	630	600	2,257	766	1,491	-166	27556	19038.73	137.9809
14	815	704	592	2,083	602	1,481	-10	100	17460.5	132.1382
15	640	815	662	2,143	750	1,393	-88	7744	16713.08	129.2791
16	798	640	766	2,159	743	1,416	23	529	15557.07	124.728
17	790	798	602	2,018	604	1,414	-2	4	14520.2	120.4998
18	643	790	750	2,164	754	1,410	-4	16	13613.69	116.6777
19	802	643	743	2,153	765	1,388	-22	484	12841.35	113.3197
20	814	802	604	1,992	806	1,186	-202	40804	14394.83	119.9785
21	857	814	754	1,940	660	1,280	94	8836	14102.26	118.753
22	702	857	765	2,045	661	1,384	104	10816	13937.95	118.0591
23	703	702	806	2,190	541	1,649	265	70225	16618.29	128.9119
24	576	703	660	2,309	640	1,669	20	400	15881.09	126.0202
25	681	576	661	2,330	636	1,694	25	625	15217.78	123.3604
26	677	681	541	2,235	622	1,613	-81	6561	14857.08	121.8896
27	662	677	640	2,253	598	1,655	42	1764	14333.36	119.722
28	636	662	636	2,291	551	1,740	85	7225	14059.96	118.5747
29	586	636	622	2,362	643	1,719	-21	441	13555.56	116.4283
30	684	586	598	2,317	656	1,661	-58	3364	13191.57	114.8546
31	698	684	551	2,212	728	1,484	-177	31329	13817	117.5457
32	774	698	643	2,127	758	1,369	-115	13225	13797.27	117.4618
33	806	774	656	2,025	687	1,338	-31	961	13383.19	115.6858
					Average	1,496	-6			

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APPENDIX B4

Model 2: 65413-00

Simulation using Previous Demand Data + 6% Chroming Fall-out											
				York		York	8TH	SE			
	Salinas	X-it	X-it	Avail	Cust	Ending	Week	Signal	SE		SD
Time	Production	Ne	York	Inv	Demand	Inv	F'Cast	Error	Squared	MSE	RMSE
							1620				
1	1723	1700	1700	2937	1800	1100	1620				
2	1723	1723	1598	2698	1800	898	1680				
3	1787	1723	1620	2518	1800	718	1620	-180	32400	32400	180
4	1723	1787	1620	2338	1800	538	1620	-180	32400	32400	180
5	1723	1723	1680	2218	1800	418	1560	-120	14400	26400	162.4808
6	1660	1723	1620	2038	1440	598	1560	180	32400	27900	167.0329
7	1660	1660	1620	2218	1800	418	1920	-180	32400	28800	169.7056
8	2043	1660	1560	1978	1440	538	1860	120	14400	26400	162.4808
9	1979	2043	1560	2098	1440	658	1860	120	14400	24686	157.1169
10	1979	1979	1920	2578	1800	778	1800	120	14400	23400	152.9706
11	1915	1979	1860	2638	1500	1138	1680	360	129600	35200	187.6166
12	1787	1915	1860	2998	1860	1138	1680	0	0	31680	177.9888
13	1787	1787	1800	2938	1920	1018	1380	-120	14400	30109	173.5197
14	1468	1787	1680	2698	1860	838	1260	-180	32400	30300	174.069
15	1340	1468	1680	2518	1628	890	1680	52	2704	28177	167.8607
16	1787	1340	1380	2270	1638	632	1680	-258	66564	30919	175.8384
17	1787	1787	1260	1892	1288	604	1620	-28	784	28910	170.0298
18	1723	1787	1680	2284	1610	674	3000	70	4900	27410	165.5581
19	3191	1723	1680	2354	1654	700	1200	26	676	25837	160.7387
20	1277	3191	1620	2320	1690	630	1200	-70	4900	24674	157.0789
21	1277	1277	3000	3630	1662	1968	1500	1338	1790244	1E+05	342.9264
22	1596	1277	1200	3168	1646	1522	1860	-446	198916	1E+05	348.8042
23	1979	1596	1200	2722	1426	1296	1860	-226	51076	1E+05	343.9521
24	1979	1979	1500	2796	1800	996	1620	-300	90000	1E+05	342.0768
25	1723	1979	1860	2856	1806	1050	1620	54	2916	1E+05	334.7471
26	1723	1723	1860	2910	1804	1106	1977	56	3136	1E+05	327.8984
27	2103	1723	1620	2726	1952	774	1938	-332	110224	1E+05	328.0634
28	2062	2103	1620	2394	1504	890	1885	116	13456	1E+05	322.496
29	2005	2062	1977	2867	1736	1131	1928	241	58081	1E+05	319.8482
30	2051	2005	1938	3069	1948	1121	1978	-10	100	98653	314.0904
31	2104	2051	1885	3006	2014	992	624	-129	16641	95825	309.5557
32	664	2104	1928	2920	2127	793	624	-199	39601	93951	306.5137
33	664	664	1978	2771	2123	648	685	-145	21025	91598	302.6519
					Average	878		-8			

Model 2: 65538-95A

Simulation using Previous Demand Data + 6% Chroming Fall-out											
				York		York	8TH	SE			
	Salinas	X-it	X-it	Avail	Cust	Ending	Week	Signal	SE		SD
Time	Production	Ne	York	Inv	Demand	Inv	F'Cast	Error	Squared	MSE	RMSE
	1000				940		945				
1	1005	1000	940	1836	940	896	942				
2	1002	1005	940	1836	940	896	945				
3	1005	1002	945	1841	1000	901	989	-55	3025	3025.00	55.00
4	1052	1005	942	1843	989	843	1031	-47	2209	2617.00	51.16
5	1097	1052	945	1788	1040	799	1032	-95	9025	4753.00	68.94
6	1098	1097	989	1788	1100	748	1035	-111	12321	6645.00	81.52
7	1101	1098	1031	1779	762	679	1039	269	72361	19788.20	140.67
8	1105	1101	1032	1711	1158	949	1060	-126	15876	19136.17	138.33
9	1128	1105	1035	1984	679	826	1061	356	126736	34507.57	185.76
10	1129	1128	1039	1865	1052	1186	1063	-13	169	30215.25	173.83
11	1131	1129	1060	2246	1167	1194	1066	-107	11449	28130.11	167.72
12	1134	1131	1061	2255	1077	1088	1209	-16	256	25342.70	159.19
13	1286	1134	1063	2151	1066	1074	1118	-3	9	23039.64	151.79
14	1189	1286	1066	2140	1251	1074	894	-185	34225	23971.75	154.83
15	951	1189	1209	2283	1161	1032	1090	48	2304	22305.00	149.35
16	1160	951	1118	2150	1164	989	1130	-46	2116	20862.93	144.44
17	1202	1160	894	1883	923	719	1138	-29	841	19528.13	139.74
18	1211	1202	1090	1809	1154	886	1136	-64	4096	18563.63	136.25
19	1209	1211	1130	2016	1143	862	1944	-13	169	17481.59	132.22
20	2068	1209	1138	2000	1096	857	1100	42	1764	16608.39	128.87
21	1170	2068	1136	1993	1087	897	1100	49	2401	15860.63	125.94
22	1170	1170	1944	2841	1082	1754	1158	862	743044	52219.80	228.52
23	1232	1170	1100	2854	862	1772	1139	238	56644	52430.48	228.98
24	1212	1232	1100	2872	1100	2010	892	0	0	50047.27	223.71
25	949	1212	1158	3168	1100	2068	932	58	3364	48017.57	219.13
26	991	949	1139	3207	1100	2107	1128	39	1521	46080.21	214.66
27	1200	991	892	2999	1117	1899	1167	-225	50625	46262.00	215.09
28	1241	1200	932	2831	906	1714	1141	26	676	44508.69	210.97
29	1214	1241	1128	2842	1084	1936	1127	44	1936	42931.93	207.20
30	1199	1214	1167	3103	1129	2019	1135	38	1444	41450.21	203.59
31	1207	1199	1141	3160	1149	2031	1123	-8	64	40023.10	200.06
32	1195	1207	1127	3158	1151	2009	1219	-24	576	38708.20	196.74
33	1297	1195	1135	3144	1107	1993	1145	28	784	37484.84	193.61
						1294.5		30			

Model 2: 65890-00

Simulation using Previous Demand Data + 6% Chroming Fall-out as Input											
				York		York	8TH	SE			
	Salinas	X-it	X-it	Avail	Cust	Ending	Week	Signal	SE		SD
Time	Production	Ne	York	Inv	Demand	Inv	F'Cast	Error	Squared	MSE	RMSE
	780				664		**780**				
1	830	780	706	1,344	664	680	720				
2	766	830	733	1,413	664	749	720				
3	766	766	780	1,529	544	865	720	236	55696	55696	236
4	766	766	720	1,585	695	1,041	720	25	625	28160.5	167.8109
5	766	766	720	1,761	680	1,066	720	40	1600	19307	138.9496
6	766	766	720	1,786	782	1,106	780	-62	3844	15441.25	124.2628
7	830	766	720	1,826	756	1,044	600	-36	1296	12612.2	112.3041
8	638	830	720	1,764	782	1,008	600	-62	3844	11150.83	105.5975
9	638	638	780	1,788	604	1,006	600	176	30976	13983	118.2497
10	638	638	600	1,606	600	1,002	660	0	0	12235.13	110.6125
11	702	638	600	1,602	592	1,002	720	8	64	10882.78	104.3206
12	766	702	600	1,602	662	1,010	720	-62	3844	10178.9	100.8905
13	766	766	660	1,670	766	1,008	600	-106	11236	10275	101.3657
14	638	766	720	1,728	602	962	600	118	13924	10579.08	102.8547
15	638	638	720	1,682	750	1,080	780	-30	900	9834.538	99.16924
16	830	638	600	1,680	743	930	660	-143	20449	10592.71	102.9209
17	702	830	600	1,530	604	787	660	-4	16	9887.6	99.43641
18	702	702	780	1,567	754	963	1,200	26	676	9311.875	96.49806
19	1,277	702	660	1,623	765	869	480	-105	11025	9412.647	97.0188
20	511	1,277	660	1,529	806	764	0	-146	21316	10073.94	100.369
21	0	511	1,200	1,964	660	1,158	480	540	291600	24891.11	157.7692
22	511	0	480	1,638	661	978	600	-181	32761	25284.6	159.0113
23	638	511	0	978	541	317	660	-541	292681	38017.76	194.9814
24	702	638	480	797	640	256	600	-160	25600	37453.32	193.5286
25	638	702	600	856	636	216	600	-36	1296	35881.26	189.4235
26	638	638	660	876	622	240	702	38	1444	34446.38	185.5973
27	747	638	600	840	598	218	712	2	4	33068.68	181.848
28	757	747	600	818	551	220	715	49	2401	31889.15	178.5753
29	761	757	702	922	643	371	719	59	3481	30837	175.6047
30	765	761	712	1,083	656	440	536	56	3136	29847.68	172.7648
31	570	765	715	1,155	728	499	715	-13	169	28824.28	169.7771
32	761	570	719	1,218	758	490	719	-39	1521	27914.17	167.0753
33	765	761	536	1,026	687	268	536	-151	22801	27749.23	166.581
						746		**-16**			

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APPENDIX B5

Model 3: 65413-00

Simulation using Corrected Forecast Data + 6% Chroming Fall-out											
				York		York	8TH	SE			
	Salinas	X-it	X-it	Avail	Cust	Ending	Week	Signal	SE		SD
Time	Production	Ne	York	Inv	Demand	Inv	F'Cast	Error	Squared	MSE	RMSE
							1620				
1	1732	1700	1700	2937	1800	1137	1620				
2	1732	1732	1598	2735	1800	935	1680				
3	1796	1732	1628	2563	1800	763	1620	-172	29584	29584	172
4	1732	1796	1628	2391	1800	591	1620	-172	29584	29584	172
5	1732	1732	1688	2279	1800	479	1560	-112	12544	23904	154.6092
6	1668	1732	1628	2107	1440	667	1560	188	35344	26764	163.5971
7	1668	1668	1628	2295	1800	495	1920	-172	29584	27328	165.3118
8	2051	1668	1568	2063	1440	623	1860	128	16384	25504	159.6997
9	1987	2051	1568	2191	1440	751	1860	128	16384	24201	155.5672
10	1987	1987	1928	2679	1800	879	1800	128	16384	23224	152.3942
11	1923	1987	1868	2747	1500	1247	1680	368	135424	35691	188.9197
12	1796	1923	1868	3115	1860	1255	1680	8	64	32128	179.2429
13	1796	1796	1808	3063	1920	1143	1380	-112	12544	30348	174.2057
14	1477	1796	1688	2831	1860	971	1260	-172	29584	30284	174.023
15	1349	1477	1688	2659	1628	1031	1680	60	3600	28231	168.022
16	1796	1349	1388	2419	1638	781	1680	-250	62500	30679	175.1546
17	1796	1796	1268	2049	1288	761	1620	-20	400	28661	169.2942
18	1732	1796	1688	2449	1610	839	3000	78	6084	27250	165.0742
19	3200	1732	1688	2527	1654	873	1200	34	1156	25715	160.3577
20	1285	3200	1628	2501	1690	811	1200	-62	3844	24500	156.5233
21	1285	1285	3008	3819	1662	2157	1500	1346	1811716	1E+05	344.3306
22	1604	1285	1208	3365	1646	1719	1860	-438	191844	1E+05	349.6106
23	1987	1604	1208	2927	1426	1501	1860	-218	47524	1E+05	344.4855
24	1987	1987	1508	3009	1800	1209	1620	-292	85264	1E+05	342.2745
25	1732	1987	1868	3077	1806	1271	1620	62	3844	1E+05	335.0006
26	1732	1732	1868	3139	1804	1335	1977	64	4096	1E+05	328.2073
27	2112	1732	1628	2963	1952	1011	1938	-324	104976	1E+05	328.04
28	2070	2112	1628	2639	1504	1135	1885	124	15376	1E+05	322.5876
29	2014	2070	1985	3120	1736	1384	1928	249	62001	1E+05	320.1639
30	2060	2014	1946	3330	1948	1382	1978	-2	4	98844	314.3949
31	2113	2060	1893	3275	2014	1261	624	-121	14641	95941	309.7428
32	672	2113	1936	3197	2127	1070	624	-191	36481	93959	306.5267
33	672	672	1986	3056	2123	933	685	-137	18769	91533	302.5445
					Average	1042		0			

Model 3: 65538-95A

Simulation using Corrected Forecast Data + 6% Chroming Fall-out

Time	Salinas Production	X-it Ne	X-it York	York Avail Inv	Cust Demand	York Ending Inv	8TH Week F'Cast	SE Signal Error	SE Squared	MSE	SD RMSE
	1000				940		945				
1	967	1000	940	1827	940	887	942				
2	964	967	940	1827	940	887	945				
3	967	964	909	1796	1000	856	989	0	0	0.00	0.00
4	1014	967	906	1762	989	762	1031	-91	8281	4140.50	64.35
5	1059	1014	909	1671	1040	682	1032	-83	6889	5056.67	71.11
6	1060	1059	953	1635	1100	595	1035	-131	17161	8082.75	89.90
7	1063	1060	995	1590	762	490	1039	-147	21609	10788.00	103.87
8	1067	1063	996	1486	1158	724	1060	233	54289	18038.17	134.31
9	1089	1067	999	1723	679	565	1061	-162	26244	19210.43	138.60
10	1090	1089	1003	1568	1052	889	1063	320	102400	29609.13	172.07
11	1093	1090	1024	1913	1167	861	1066	-49	2401	26586.00	163.05
12	1096	1093	1025	1886	1077	719	1209	-143	20449	25972.30	161.16
13	1248	1096	1027	1746	1066	669	1118	-52	2704	23857.00	154.46
14	1151	1248	1030	1699	1251	633	894	-39	1521	21995.67	148.31
15	913	1151	1173	1806	1161	555	1090	-221	48841	24060.69	155.12
16	1121	913	1082	1637	1164	476	1130	12	144	22352.36	149.51
17	1164	1121	858	1334	923	170	1138	-82	6724	21310.47	145.98
18	1172	1164	1054	1224	1154	301	1136	-65	4225	20242.63	142.28
19	1170	1172	1094	1395	1143	241	1944	-100	10000	19640.12	140.14
20	2030	1170	1102	1343	1096	200	1100	-49	2401	18682.39	136.68
21	1132	2030	1100	1300	1087	204	1100	6	36	17701.00	133.05
22	1132	1132	1908	2112	1082	1025	1158	13	169	16824.40	129.71
23	1194	1132	1064	2089	862	1007	1139	826	682276	48512.57	220.26
24	1173	1194	1064	2071	1100	1209	892	202	40804	48162.18	219.46
25	911	1173	1122	2331	1100	1231	932	-36	1296	46124.52	214.77
26	953	911	1103	2334	1100	1234	1128	22	484	44222.83	210.29
27	1162	953	856	2090	1117	990	1167	3	9	42454.28	206.04
28	1203	1162	896	1886	906	769	1141	-261	68121	43441.46	208.43
29	1176	1203	1092	1861	1084	955	1127	-10	100	41836.22	204.54
30	1161	1176	1131	2086	1129	1002	1135	8	64	40344.36	200.86
31	1169	1161	1105	2107	1149	978	1123	2	4	38953.31	197.37
32	1156	1169	1091	2069	1151	920	1219	-44	1936	37719.40	194.21
33	1259	1156	1099	2019	1107	868	1145	-60	3600	36618.77	191.36
						744.33		-6			

Model 3: 65890-00

Simulation using Corrected Forecast Data + 6% Chroming Fall-out as Input											
Time	Salinas Production	X-it Ne	X-it York	York Avail Inv	Cust Demand	York Ending Inv	8TH Week F'Cast	SE Signal Error	SE Squared	MSE	SD RMSE
	780				664		**780**				
1	849	780	706	1,341	664	677	720				
2	785	849	733	1,410	664	746	720				
3	785	785	798	1,544	544	880	720	254	64516	64516	254
4	785	785	738	1,618	695	1,074	720	43	1849	33182.5	182.1606
5	785	785	738	1,812	680	1,117	720	58	3364	23243	152.4566
6	785	785	738	1,855	782	1,175	780	-44	1936	17916.25	133.8516
7	849	785	738	1,913	756	1,131	600	-18	324	14397.8	119.9908
8	657	849	738	1,869	782	1,113	600	-44	1936	12320.83	110.9992
9	657	657	798	1,911	604	1,129	600	194	37636	15937.29	126.243
10	657	657	618	1,747	600	1,143	660	18	324	13985.63	118.2608
11	721	657	618	1,761	592	1,161	720	26	676	12506.78	111.8337
12	785	721	618	1,779	662	1,187	720	-44	1936	11449.7	107.0033
13	785	785	678	1,865	766	1,203	600	-88	7744	11112.82	105.4174
14	657	785	738	1,941	602	1,175	600	136	18496	11728.08	108.2963
15	657	657	738	1,913	750	1,311	780	-12	144	10837	104.1009
16	849	657	618	1,929	743	1,179	660	-125	15625	11179	105.7308
17	721	849	618	1,797	604	1,054	660	14	196	10446.8	102.2096
18	721	721	798	1,852	754	1,248	1,200	44	1936	9914.875	99.57347
19	1,296	721	678	1,926	765	1,172	480	-87	7569	9776.882	98.87812
20	530	1,296	678	1,850	806	1,085	0	-128	16384	10143.94	100.7172
21	19	530	1,218	2,303	660	1,497	480	558	311364	25997.63	161.2378
22	530	19	498	1,995	661	1,335	600	-163	26569	26026.2	161.3264
23	657	530	18	1,353	541	692	660	-523	273529	37812.05	194.4532
24	721	657	498	1,190	640	649	600	-142	20164	37009.86	192.3795
25	657	721	618	1,267	636	627	600	-18	324	35414.83	188.1883
26	657	657	678	1,305	622	669	702	56	3136	34069.88	184.5803
27	766	657	618	1,287	598	665	712	20	400	32723.08	180.8952
28	777	766	618	1,283	551	685	715	67	4489	31637.15	177.8684
29	780	777	720	1,405	643	854	719	77	5929	30685	175.1713
30	784	780	730	1,584	656	941	536	74	5476	29784.68	172.5824
31	589	784	733	1,674	728	1,018	715	5	25	28758.48	169.5833
32	780	589	737	1,755	758	1,027	719	-21	441	27814.57	166.777
33	784	780	554	1,581	687	823	536	-133	17689	27487.94	165.7949
						1,014		2			

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APPENDIX B6

Model 4: 65413-00

Simulation using Gabilan Signal Data + 6% Chroming Fall-out											
				York		York	8TH	SE			
	Salinas	X-it	X-it	Avail	Cust	Ending	Week	Signal	SE		SD
Time	Production	Ne	York	Inv	Demand	Inv	F'Cast	Error	Squared	MSE	RMSE
							1620				
1	1700	1700	1700	3240	2000	1240	1620				
2	1695	1700	1598	2838	1800	1038	1680				
3	1800	1695	1598	2636	1800	836	1620	-202	40804	40804	202
4	1800	1800	1593	2429	1800	629	1620	-207	42724.89	41764	204.3635
5	1800	1800	1692	2321	1800	521	1560	-108	11664	31731	178.1319
6	2000	1800	1692	2213	1440	773	1560	252	63504	39674	199.1839
7	2000	2000	1692	2465	1800	665	1920	-108	11664	34072	184.5865
8	2000	2000	1880	2545	1440	1105	1860	440	193600	60660	246.2928
9	2000	2000	1880	2985	1440	1545	1860	440	193600	79652	282.2261
10	1800	2000	1880	3425	1800	1625	1800	80	6400	70495	265.5092
11	1900	1800	1880	3505	1500	2005	1680	380	144400	78707	280.5473
12	2100	1900	1692	3697	1860	1837	1680	-168	28224	73658	271.401
13	1900	2100	1786	3623	1920	1703	1380	-134	17956	68595	261.9058
14	1700	1900	1974	3677	1860	1817	1260	114	12996	63961	252.9059
15	1700	1700	1786	3603	1628	1975	1680	158	24964	60962	246.904
16	1500	1700	1598	3573	1638	1935	1680	-40	1600	56721	238.1627
17	2200	1500	1598	3533	1288	2245	1620	310	96100	59347	243.6118
18	2000	2200	1410	3655	1610	2045	3000	-200	40000	58138	241.1173
19	1900	2000	2068	4113	1654	2459	1200	414	171396	64800	254.5581
20	2300	1900	1880	4339	1690	2649	1200	190	36100	63205	251.4068
21	2100	2300	1786	4435	1662	2773	1500	124	15376	60688	246.3494
22	2100	2100	2162	4935	1646	3289	1860	516	266256	70966	266.3953
23	1000	2100	1974	5263	1426	3837	1860	548	300304	81887	286.1595
24	1900	1000	1470	5307	1800	3507	1620	-330	108900	83115	288.2969
25	2100	1900	700	4207	1806	2401	1620	-1106	1223236	132686	364.2604
26	2800	2100	1330	3731	1804	1927	1977	-474	224676	136519	369.4841
27	2100	2800	1470	3397	1952	1445	1938	-482	232324	140351	374.6342
28	2000	2100	1960	3405	1504	1901	1885	456	207936	142950	378.0875
29	2300	2000	1470	3371	1736	1635	1928	-266	70756	140276	374.5348
30	2500	2300	1400	3035	1948	1087	1978	-548	300304	145992	382.0885
31	2200	2500	1610	2697	2014	683	624	-404	163216	146586	382.8649
32	2000	2200	1750	2433	2127	306	624	-377	142129	146437	382.6709
33	1500	2000	2068	2374	2123	251	685	-55	3025	141811	376.5778
						1723		-25			

Model 4: 65538-95A

Simulation using Gabilan Signal Data + 6% Chroming Fall-out											
				York		York	8TH	SE			
	Salinas	X-it	X-it	Avail	Cust	Ending	Week	Signal	SE		SD
Time	Production	Ne	York	Inv	Demand	Inv	F'Cast	Error	Squared	MSE	RMSE
					940		945				
1	1100	990	945	1830	940	890	942				
2	1100	1100	931	1821	940	881	945				
3	1100	1100	1034	1915	1000	915	989	34	1156	1156.00	34.00
4	1040	1100	1034	1949	989	960	1031	45	2025	1590.50	39.88
5	1200	1040	1034	1994	1040	954	1032	-6	36	1072.33	32.75
6	1200	1200	978	1931	1100	831	1035	-122.4	14981.76	4549.69	67.45
7	1200	1200	1128	1959	762	1197	1039	366	133956	30430.95	174.44
8	1200	1200	1128	2325	1158	1167	1060	-30	900	25509.13	159.72
9	1200	1200	1128	2295	679	1616	1061	449	201601	50665.11	225.09
10	1120	1200	1128	2744	1052	1692	1063	76	5776	45053.97	212.26
11	1200	1120	1128	2820	1167	1653	1066	-39	1521	40216.97	200.54
12	1120	1200	1053	2706	1077	1629	1209	-24.2	585.64	36253.84	190.40
13	1200	1120	1128	2757	1066	1691	1118	62	3844	33307.49	182.50
14	1120	1200	1053	2744	1251	1493	894	-198.2	39283.24	33805.47	183.86
15	1120	1120	1128	2621	1161	1460	1090	-33	1089	31288.82	176.89
16	1120	1120	1053	2513	1164	1349	1130	-111.2	12365.44	29937.15	173.02
17	1200	1120	1053	2401	923	1478	1138	129.8	16848.04	29064.54	170.48
18	1120	1200	1053	2531	1154	1377	1136	-101.2	10241.44	27888.10	167.00
19	1200	1120	1128	2505	1143	1362	1944	-15	225	26260.86	162.05
20	1200	1200	1053	2415	1096	1319	1100	-43.2	1866.24	24905.60	157.82
21	1120	1200	1128	2447	1087	1360	1100	41	1681	23683.25	153.89
22	1280	1120	1128	2488	1082	1406	1158	46	2116	22604.89	150.35
23	720	1280	1053	2459	862	1597	1139	190.8	36404.64	23262.02	152.52
24	1200	720	1203	2800	1100	1700	892	103.2	10650.24	22688.76	150.63
25	1200	1200	677	2377	1100	1277	932	-423.2	179098.2	29489.17	171.72
26	1280	1200	1128	2405	1100	1305	1128	28	784	28293.12	168.21
27	1200	1280	1128	2433	1117	1316	1167	11	121	27166.24	164.82
28	560	1200	1203	2519	906	1613	1141	297.2	88327.84	29518.61	171.81
29	1200	560	1128	2741	1084	1657	1127	44	1936	28497.03	168.81
30	1120	1200	526	2183	1129	1054	1135	-602.6	363126.8	40448.09	201.12
31	1200	1120	1128	2182	1149	1033	1123	-21	441	39068.54	197.66
32	1200	1200	1053	2086	1151	935	1219	-98.2	9643.24	38087.69	195.16
33	1360	1200	1128	2063	1107	956	1145	21	441	36873.28	192.02
						1306.7		**2**			

Model 4: 65890-00

Simulation using Gabilan Signal Data + 6% Chroming Fall-out as Input											
				York		York	8TH	SE			
	Salinas	X-it	X-it	Avail	Cust	Ending	Week	Signal	SE		SD
Time	Production	Ne	York	Inv	Demand	Inv	F'Cast	Error	Squared	MSE	RMSE
					664		**780**				
1	706	706	706	1,698	664	1,034	720				
2	706	706	664	1,697	664	1,033	720				
3	706	706	664	1,697	544	1,153	720	120	14400	14400	120
4	640	706	664	1,817	695	1,122	720	-31	961	7680.5	87.63846
5	720	640	664	1,786	680	1,106	720	-16	256	5205.667	72.15031
6	900	720	602	1,708	782	926	780	-180.4	32544.16	12040.29	109.7283
7	800	900	677	1,603	756	847	600	-79.2	6272.64	10886.76	104.3396
8	720	800	846	1,693	782	911	600	64	4096	9754.967	98.76723
9	960	720	752	1,663	604	1,059	600	148	21904	11490.54	107.1939
10	800	960	677	1,736	600	1,136	660	76.8	5898.24	10791.51	103.8822
11	880	800	902	2,038	592	1,446	720	310.4	96348.16	20297.8	142.4703
12	640	880	752	2,198	662	1,536	720	90	8100	19078.02	138.1232
13	880	640	827	2,363	766	1,597	600	61.2	3745.44	17684.15	132.9818
14	880	880	602	2,199	602	1,597	600	-0.4	0.16	16210.48	127.3204
15	1,200	880	827	2,424	750	1,674	780	77.2	5959.84	15421.97	124.1852
16	1,040	1,200	827	2,501	743	1,758	660	84.2	7089.64	14826.81	121.7654
17	960	1,040	1,128	2,886	604	2,282	660	524	274576	32143.42	179.2859
18	960	960	978	3,260	754	2,506	1,200	223.6	49996.96	33259.27	182.3712
19	1,040	960	902	3,408	765	2,643	480	137.4	18878.76	32413.35	180.0371
20	800	1,040	902	3,546	806	2,740	0	96.4	9292.96	31128.89	176.4338
21	960	800	978	3,717	660	3,057	480	317.6	100869.8	34799.46	186.5461
22	1,040	960	752	3,809	661	3,148	600	91	8281	33473.54	182.9577
23	480	1,040	902	4,051	541	3,510	660	361.4	130610	38099.08	195.1899
24	720	480	978	4,487	640	3,847	600	337.6	113973.8	41547.93	203.8331
25	800	720	451	4,298	636	3,662	600	-184.8	34151.04	41226.33	203.0427
26	320	800	677	4,339	622	3,717	702	54.8	3003.04	39633.69	199.0821
27	0	320	752	4,469	598	3,871	712	154	23716	38996.98	197.4765
28	0	0	301	4,172	551	3,621	715	-250.2	62600.04	39904.79	199.7618
29	800	0	0	3,621	643	2,978	719	-643	413449	53739.76	231.8184
30	640	800	0	2,978	656	2,322	536	-656	430336	67189.63	259.2096
31	400	640	752	3,074	728	2,346	715	24	576	64892.61	254.7403
32	400	400	602	2,948	758	2,190	719	-156.4	24460.96	63544.88	252.0811
33	480	400	376	2,566	687	1,879	536	-311	96721	64615.08	254.195
						2,129		**27**			

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APPENDIX C1

Production Log Inputs

Date	Part Number	Qty	Date	Part Number	Qty	Date	Part Number	Qty	Date	Part Number	Qty
6/2	200001	708	6/10	700009	1,001	6/19	200001	4,017	6/27	200403	187
6/2	200019	905	6/11	200008	573	6/19	200052	1,036	6/27	200405	715
6/2	200024	1,147	6/11	200011	1	6/19	200402	578	6/27	200418	271
6/2	200053	718	6/11	200014	1,010	6/19	200406	822	6/27	200420	114
6/2	200406	517	6/11	200019	2,117	6/19	200415	650	6/27	200429	864
6/2	200416	842	6/11	200402	1151	6/19	200416	543	6/27	200438	1,471
6/2	200420	657	6/11	200407	236	6/19	200428	65	6/27	700015	1,430
6/2	200429	1,216	6/11	200408	329	6/19	200429	1,153	6/27	700019	205
6/2	200438	1,099	6/11	200416	945	6/19	200438	515	6/27	700020	175
6/2	200443	44	6/11	200418	37	6/19	700000	1,311	6/27	700022	202
6/2	700000	1,830	6/11	200419	787	6/19	700004	170	6/28	130110	8,898
6/2	700012	2,217	6/11	200428	178	6/19	700007	259	6/30	200039	353
6/2	700012	1,509	6/11	200429	251	6/19	700008	308	6/30	200056	650
6/2	700016	335	6/11	200438	463	6/19	700008	252	6/30	200060	587
6/2	700025	143	6/11	200449	250	6/19	700012	1,569	6/30	200402	108
6/3	200001	1,910	6/11	700008	317	6/19	700017	203	6/30	200402	79
6/3	200031	312	6/11	700014	2,000	6/19	700018	402	6/30	200402	161
6/3	200032	1212	6/11	700017	105	6/19	700019	88	6/30	200402	191
6/3	200034	2,604	6/11	700018	105	6/19	700023	113	6/30	200402	185
6/3	200038	6,064	6/11	700019	400	6/19	700024	113	6/30	200402	104
6/3	200040	746	6/12	200014	1,200	6/20	200004	2,803	6/30	200402	271
6/3	200056	300	6/12	200014	2,259	6/20	200008	158	6/30	200402	304
6/3	200406	938	6/12	200032	426	6/20	200405	480	6/30	200407	486
6/3	200415	900	6/12	200062	1,311	6/20	200408	461	6/30	200408	745
6/3	200416	567	6/12	200402	670	6/20	700019	130	6/30	200410	605
6/3	200420	730	6/12	200406	1,080	6/20	740022	470	6/30	200416	193
6/3	200429	1,036	6/12	200416	666	6/20	740023	380	6/30	200416	1009
6/3	200438	1,503	6/12	200429	1,565	6/23	200008	2,583	6/30	200418	452
6/3	200443	300	6/12	200455	300	6/23	200010	686	6/30	200419	1021
6/3	700019	258	6/12	200467	400	6/23	200032	321	6/30	200419	303
6/3	740030	102	6/12	200468	246	6/23	200032	156	6/30	200420	7
6/4	130110	11,300	6/12	700001	941	6/23	200036	1,301	6/30	200420	70
6/4	200033	1,072	6/12	700002	1,467	6/23	200038	7,322	6/30	200438	480
6/4	200034	3,235	6/12	700003	480	6/23	200070	125	6/30	200444	186
6/4	200038	1,225	6/12	700011	55	6/23	200401	88	6/30	200444	216
6/4	200402	179	6/12	700013	879	6/23	200402	34	6/30	200444	108
6/4	200407	130	6/12	700025	110	6/23	200403	700	6/30	200458	54
6/4	200416	1,206	6/12	740030	200	6/23	200404	510	6/30	200458	45
6/4	200418	400	6/13	200406	680	6/23	200408	529	6/30	700008	251
6/4	200420	526	6/13	200408	96	6/23	200416	1,265	6/30	700008	406
6/4	200429	584	6/13	200416	847	6/23	200418	347	6/30	700023	123
6/4	200449	225	6/13	200429	350	6/23	200419	179	6/30	740001	98
6/4	200467	100	6/13	200438	363	6/23	200429	786	6/30	740001	1998
6/4	700003	66	6/13	200469	250	6/23	200439	328			
6/4	700008	792	6/13	700008	226	6/24	200006	676			
6/4	700008	126	6/13	700023	110	6/24	200031	350			
6/4	700011	95	6/13	700024	121	6/24	200032	1012			
6/5	200004	383	6/16	200001	2,408	6/24	200033	3,207			
6/5	200006	10	6/16	200004	2,895	6/24	200037	1,571			
6/5	200406	313	6/16	200032	646	6/24	200043	554			
6/5	200408	749	6/16	200035	989	6/24	200056	240			
6/5	200419	1,000	6/16	200041	552	6/24	200401	377			
6/5	200420	627	6/16	200402	1479	6/24	200406	767			
6/5	200429	913	6/16	200404	295	6/24	200407	448			
6/5	200438	3,288	6/16	200406	309	6/24	200414	657			
6/5	200469	123	6/16	200408	208	6/24	200416	660			
6/5	700009	160	6/16	200409	273	6/24	200418	108			
6/6	200036	1,655	6/16	200414	861	6/24	200419	750			
6/6	200037	3,151	6/16	200415	875	6/24	200425	630			
6/6	200408	160	6/16	200429	987	6/24	200429	176			
6/6	200416	630	6/16	200438	994	6/24	200438	236			
6/6	200420	244	6/17	200006	282	6/24	200449	400			
6/6	200429	630	6/17	200009	395	6/24	700008	437			
6/6	200467	45	6/17	200032	761	6/25	200001	2,735			
6/7	200001	2,624	6/17	200035	943	6/25	200004	2,643			
6/7	200036	622	6/17	200037	148	6/25	200006	2,018			
6/9	200001	2,475	6/17	200037	286	6/25	200008	1,940			
6/9	200003	1,084	6/17	200041	2,645	6/25	200040	701			

Part Sizes

Part Number	Length (inches)	Part Number	Length (inches)
130110	0.25	200534	8.63
200001	4.03	700000	3.12
200003	3.09	700001	4.815
200004	3.7	700002	1.5
200006	5.01	700003	22
200007	2.72	700004	17.55
200008	5.47	700006	2.64
200009	11.41	700007	17.5
200010	3.34	700008	13.41
200011	3.78	700009	3.5
200014	1.78	700011	36
200015	2.34	700012	2.04
200019	1.78	700013	3.315
200020	10.75	700014	1.99
200022	20	700015	3.9
200024	5.09	700016	17.74
200031	9.645	700017	0.903
200032	3.88	700018	1.094
200033	1.915	700019	5.45
200034	2.505	700020	17.25
200035	9.89	700022	20.04
200036	5.84	700023	3.83
200037	6.25	700024	5.09
200038	1.46	700025	13.38
200039	8.34	700032	10
200040	4.69	740001	2.26
200041	5.15	740005	5
200043	8.82	740007	13.38
200044	4.4	740022	12
200046	3.94	740023	15
200048	2.515	740030	6.13
200052	1.56		
200053	7.06		
200055	5.29		
200056	11.41		
200057	4.67		
200060	1.46		
200061	3.06		
200062	3.25		
200068	12.53		
200069	12.02		
200070	12.53		
200071	8.1		
200073	16.53		
200401	18.16		
200402	19.06		
200403	17.34		
200404	19.34		
200405	13.72		
200406	15.94		
200407	17.66		
200408	15.94		
200409	11.28		
200410	15.94		
200411	11.53		
200414	10.28		
200415	8.78		
200416	16.75		
200418	18.43		
200419	14.23		
200420	20.24		
200421	17.66		
200424	15.25		
200425	17.6		
200426	12.75		
200428	14.13		
200429	19.84		

Cutting Production

	01-07 June		08-14 June		15-21 June		22-28 June		29-30 June		Montly Totals:			
Part #	Numbe	Size of Cut	Numbe	Size of Cut	Numb	Size of Cut	Numbe	Size of Cut	Numb	Size of Cut	Number	Size of Cut	Part #	Cut
130110	11,300	235.4167	0	0.0000	0	0.0000	10,628	221.4167	0	0.0000	21,928	456.8333	130110	0.25
200001	5,242	1,760.4383	2,475	831.1875	2,408	808.6867	5,584	1,875.2933	0	0.0000	15,709	5,275.6058	200001	4.03
200003	0	0.0000	1,084	279.1300	0	0.0000	0	0.0000	0	0.0000	1,084	279.1300	200003	3.09
200004	383	118.0917	2,865	883.3750	4,900	1,510.8333	6,171	1,902.7250	0	0.0000	14,319	4,415.0250	200004	3.7
200006	10	4.1750	1,922	802.4350	1,919	801.1825	2,694	1,124.7450	0	0.0000	6,545	2,732.5375	200006	5.01
200007	0	0.0000	1,044	236.6400	0	0.0000	766	173.6267	0	0.0000	1,810	410.2667	200007	2.72
200008	0	0.0000	0	0.0000	0	0.0000	4,754	2,167.0317	0	0.0000	4,754	2,167.0317	200008	5.47
200009	0	0.0000	315	299.5125	748	711.2233	0	0.0000	0	0.0000	1,063	1,010.7358	200009	11.41
200010	0	0.0000	0	0.0000	0	0.0000	686	190.9367	0	0.0000	686	190.9367	200010	3.34
200011	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	200011	3.78
200014	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	200014	1.78
200015	0	0.0000	0	0.0000	981	191.2950	0	0.0000	0	0.0000	981	191.2950	200015	2.34
200019	905	134.2417	0	0.0000	0	0.0000	0	0.0000	0	0.0000	905	134.2417	200019	1.78
200024	1,147	486.5192	0	0.0000	0	0.0000	0	0.0000	0	0.0000	1,147	486.5192	200024	5.09
200031	312	250.7700	623	500.7363	205	164.7688	791	635.7663	0	0.0000	1,931	1,552.0413	200031	9.645
200032	1,212	391.8800	0	0.0000	1,407	454.9300	1,489	481.4433	0	0.0000	4,108	1,328.2533	200032	3.88
200033	1,072	171.0733	0	0.0000	0	0.0000	3,207	511.7838	0	0.0000	4,279	682.8571	200033	1.915
200034	5,839	1,218.8913	0	0.0000	0	0.0000	0	0.0000	0	0.0000	5,839	1,218.8913	200034	2.505
200035	0	0.0000	973	801.9142	1,932	1,592.2900	0	0.0000	0	0.0000	2,905	2,394.2042	200035	9.89
200036	2,277	1,108.1400	0	0.0000	0	0.0000	1,301	633.1533	0	0.0000	3,578	1,741.2933	200036	5.84
200037	3,151	1,641.1458	1,522	792.7083	434	226.0417	3,111	1,620.3125	0	0.0000	8,218	4,280.2083	200037	6.25
200038	7,289	886.8283	0	0.0000	0	0.0000	7,322	890.8433	0	0.0000	14,611	1,777.6717	200038	1.46
200040	746	291.5617	725	283.3542	0	0.0000	701	273.9742	0	0.0000	2,172	848.8900	200040	4.69
200041	0	0.0000	0	0.0000	3,197	1,372.0458	0	0.0000	0	0.0000	3,197	1,372.0458	200041	5.15
200043	0	0.0000	0	0.0000	641	471.1350	554	407.1900	0	0.0000	1,195	878.3250	200043	8.82
200044	0	0.0000	774	283.8000	0	0.0000	0	0.0000	0	0.0000	774	283.8000	200044	4.4
200048	0	0.0000	0	0.0000	1,420	297.6083	0	0.0000	0	0.0000	1,420	297.6083	200048	2.515
200052	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	200052	1.56
200053	718	422.4233	0	0.0000	0	0.0000	0	0.0000	0	0.0000	718	422.4233	200053	7.06
200055	0	0.0000	0	0.0000	0	0.0000	546	240.6950	0	0.0000	546	240.6950	200055	5.29
200056	300	285.2500	0	0.0000	275	261.4792	240	228.2000	650	618.0417	1,465	1,392.9708	200056	11.41
200057	0	0.0000	0	0.0000	0	0.0000	1,000	389.1667	0	0.0000	1,000	389.1667	200057	4.67
200061	0	0.0000	0	0.0000	1,200	306.0000	0	0.0000	0	0.0000	1,200	306.0000	200061	3.06
200062	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	200062	3.25
200070	0	0.0000	0	0.0000	0	0.0000	125	130.5208	0	0.0000	125	130.5208	200070	12.53
200401	0	0.0000	0	0.0000	0	0.0000	465	703.7000	0	0.0000	465	703.7000	200401	18.16
200402	179	284.3117	1,801	2,860.5883	3,858	6,127.7900	2,265	3,597.5750	1,403	2,228.4317	9,506	15,098.6967	200402	19.06
200403	0	0.0000	300	433.5000	0	0.0000	700	1,011.5000	0	0.0000	1,000	1,445.0000	200403	17.34
200404	0	0.0000	212	341.6733	295	475.4417	510	821.9500	0	0.0000	1,017	1,639.0650	200404	19.34
200405	0	0.0000	300	343.0000	0	0.0000	0	0.0000	0	0.0000	300	343.0000	200405	13.72
200406	1,768	2,348.4933	630	836.8500	559	742.5383	1,983	2,634.0850	0	0.0000	4,940	6,561.9667	200406	15.94
200407	130	191.3167	287	422.3683	790	1,162.6167	662	974.2433	486	715.2300	2,355	3,465.7750	200407	17.66
200408	909	1,207.4550	0	0.0000	533	708.0017	1,265	1,680.3417	745	989.6083	3,452	4,585.4067	200408	15.94
200409	0	0.0000	210	197.4000	273	256.6200	0	0.0000	0	0.0000	483	454.0200	200409	11.28
200414	0	0.0000	0	0.0000	861	737.5900	657	562.8300	0	0.0000	1,518	1,300.4200	200414	10.28
200415	900	658.5000	775	567.0417	1,525	1,115.7917	553	404.6117	0	0.0000	3,753	2,745.9450	200415	8.78
200416	3,245	4,529.4792	1,800	2,512.5000	2,421	3,379.3125	4,032	5,628.0000	1,202	1,677.7917	12,700	17,727.0833	200416	16.75
200418	400	614.3333	274	420.8183	1,238	1,901.3617	455	698.8042	452	694.1967	2,819	4,329.5142	200418	18.43
200419	1,000	1,185.8333	0	0.0000	0	0.0000	929	1,101.6392	1,324	1,570.0433	3,253	3,857.5158	200419	14.23
200420	2,784	4,695.6800	0	0.0000	0	0.0000	262	441.9067	77	129.8733	3,123	5,267.4600	200420	20.24
200425	0	0.0000	419	614.5333	0	0.0000	935	1,371.3333	0	0.0000	1,354	1,985.8667	200425	17.6
200426	0	0.0000	230	244.3750	0	0.0000	0	0.0000	0	0.0000	230	244.3750	200426	12.75
200428	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	200428	14.13
200429	4,379	7,239.9467	1,923	3,179.3600	1,704	2,817.2800	2,859	4,726.8800	0	0.0000	10,865	17,963.4667	200429	19.84
200438	5,890	9,355.2833	0	0.0000	2,434	3,866.0033	2,746	4,361.5633	480	762.4000	11,550	18,345.2500	200438	19.06
200439	0	0.0000	0	0.0000	107	126.5275	328	387.8600	0	0.0000	435	514.3875	200439	14.19
200440	0	0.0000	0	0.0000	0	0.0000	214	236.8267	0	0.0000	214	236.8267	200440	13.28
200443	344	315.3333	0	0.0000	422	386.8333	0	0.0000	0	0.0000	766	702.1667	200443	11
200444	0	0.0000	0	0.0000	389	696.9583	0	0.0000	510	913.7500	899	1,610.7083	200444	21.5
200449	225	341.0625	0	0.0000	722	1,094.4317	615	932.2375	0	0.0000	1,562	2,367.7317	200449	18.19
200453	0	0.0000	215	275.3792	0	0.0000	0	0.0000	0	0.0000	215	275.3792	200453	15.37
200455	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	200455	15.68
200462	0	0.0000	405	197.7750	0	0.0000	0	0.0000	0	0.0000	405	197.7750	200462	5.86
200467	145	124.5792	300	257.7500	50	42.9583	0	0.0000	0	0.0000	495	425.2875	200467	10.31
200468	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	200468	16

APPENDIX C2

Production Log Inputs

Date	Part #	Qty	Date	Part #	Qty	Date	Part #	Qty	Date	Part #	Qty	Date	Part #	Qty	Date	Part #	Qty
7/1	200001	900	7/9	200006	3160	7/15	200004	2437	7/21	200032	149	7/24	200415	577	7/30	200070	18
7/1	200001	705	7/9	200037	806	7/15	200004	1610	7/21	200038	4132	7/24	200420	122	7/30	200402	1484
7/1	200001	1298	7/9	200040	100	7/15	200004	1359	7/21	200038	1861	7/24	200420	75	7/30	200405	100
7/1	200004	2509	7/9	200402	156	7/15	200007	452	7/21	200401	216	7/24	200420	73	7/30	200406	109
7/1	200006	1811	7/9	200402	154	7/15	200008	1631	7/21	200401	140	7/24	200438	40	7/30	200416	380
7/1	200007	439	7/9	200402	184	7/15	200031	115	7/21	200401	180	7/24	200468	315	7/30	200419	500
7/1	200037	1528	7/9	200402	23	7/15	200036	955	7/21	200402	153	7/24	200469	310	7/30	200428	500
7/1	200037	1559	7/9	200402	175	7/15	200039	1325	7/21	200402	182	7/24	200478	300	7/30	200429	450
7/1	200068	243	7/9	200402	326	7/15	200068	189	7/21	200402	127	7/24	200478	400	7/30	200429	347
7/1	200070	126	7/9	200402	214	7/15	200402	275	7/21	200402	200	7/24	200479	165	7/30	200438	12
7/1	200073	171	7/9	200402	109	7/15	200403	153	7/21	200402	20	7/24	200479	149	7/30	200439	22
7/1	200402	189	7/9	200402	234	7/15	200403	10	7/21	200405	154	7/24	200480	100	7/30	200439	412
7/1	200402	170	7/9	200402	148	7/15	200405	254	7/21	200405	251	7/24	200480	207	7/30	200439	428
7/1	200402	167	7/9	200409	227	7/15	200407	870	7/21	200408	277	7/24	200482	126	7/30	200458	103
7/1	200402	157	7/9	200416	1000	7/15	200408	281	7/21	200408	621	7/24	200482	240	7/30	200482	610
7/1	200402	171	7/9	200416	479	7/15	200419	850	7/21	200416	1065	7/24	200482	46	7/31	200015	1575
7/1	200402	235	7/9	200429	500	7/15	200420	175	7/21	200428	30	7/25	200009	207	7/31	200030	471
7/1	200402	236	7/9	200429	132	7/15	200420	333	7/21	200429	410	7/25	200010	250	7/31	200070	300
7/1	200406	481	7/9	200429	939	7/15	200428	250	7/21	200438	360	7/25	200014	782	7/31	200402	277
7/1	200416	609	7/9	200438	300	7/15	200429	787	7/21	200438	326	7/25	200031	310	7/31	200402	168
7/1	200418	400	7/9	200439	158	7/15	200478	400	7/21	200440	300	7/25	200032	661	7/31	200402	186
7/1	200429	880	7/9	200458	24	7/15	700003	333	7/21	200440	313	7/25	200032	538	7/31	200402	156
7/1	200438	1017	7/9	200458	104	7/15	700007	205	7/21	200482	450	7/25	200037	578	7/31	200402	184
7/1	200439	448	7/9	700004	238	7/16	200035	976	7/21	700002	100	7/25	200402	157	7/31	200402	124
7/1	200440	400	7/9	700007	272	7/16	200037	1520	7/21	700002	885	7/25	200402	167	7/31	200402	82
7/1	200449	260	7/9	700007	192	7/16	200037	1536	7/21	740023	185	7/25	200402	113	7/31	200409	125
7/1	200458	368	7/9	700008	501	7/16	200037	1479	7/22	200004	1042	7/25	200402	249	7/31	200415	1650
7/2	200032	794	7/9	700008	384	7/16	200040	615	7/22	200006	751	7/25	200402	173	7/31	200416	350
7/2	200402	155	7/9	700011	79	7/16	200040	1574	7/22	200006	1750	7/25	200402	155	7/31	200429	205
7/2	200402	193	7/9	740005	315	7/16	200061	226	7/22	200019	509	7/25	200402	188	7/31	200438	412
7/2	200402	172	7/10	200001	1294	7/16	200401	50	7/22	200031	174	7/25	200407	1150	7/31	200438	1610
7/2	200402	115	7/10	200001	1063	7/16	200402	15	7/22	200031	120	7/25	200415	400	7/31	200478	728
7/2	200406	504	7/10	200003	72	7/16	200402	36	7/22	200032	549	7/25	200415	450	7/31	700001	1245
7/2	200407	625	7/10	200004	229	7/16	200415	975	7/22	200046	427	7/25	200415	410	7/31	700012	600
7/2	200407	164	7/10	200004	1566	7/16	200415	400	7/22	200056	420	7/25	200429	687	7/31	740001	2006
7/2	200407	214	7/10	200004	2775	7/16	200415	200	7/22	200060	153	7/25	200429	40	7/31	740001	2006
7/2	200408	1277	7/10	200040	1219	7/16	200416	1048	7/22	200402	55	7/25	200438	1260	7/31	740005	589
7/2	200415	750	7/10	200060	325	7/16	200420	188	7/22	200402	208	7/25	200462	444			
7/2	200416	327	7/10	200071	607	7/16	200420	110	7/22	200402	98	7/25	700001	2190			
7/2	200429	350	7/10	200402	133	7/16	200420	182	7/22	200402	30	7/25	700006	434			
7/2	200429	483	7/10	200402	206	7/16	200420	113	7/22	200402	185	7/25	700009	536			
7/2	200429	210	7/10	200402	121	7/16	200420	104	7/22	200402	78	7/25	700009	428			
7/2	200429	395	7/10	200402	153	7/16	200420	46	7/22	200402	136	7/28	200006	1686			
7/2	200458	264	7/10	200416	930	7/16	200429	300	7/22	200402	449	7/28	200008	505			
7/2	700000	500	7/10	200416	232	7/16	200443	110	7/22	200407	102	7/28	200035	945			
7/2	700002	1626	7/10	200416	148	7/16	200443	68	7/22	200409	157	7/28	200036	1684			
7/2	700004	232	7/10	200418	125	7/16	200458	106	7/22	200428	450	7/28	200037	1030			
7/2	700006	1443	7/10	200418	35	7/16	200458	116	7/22	200428	120	7/28	200037	1455			
7/2	700009	1415	7/10	200426	35	7/16	200482	431	7/22	200428	250	7/28	200039	861			
7/3	200019	2814	7/10	200438	1267	7/16	700003	70	7/22	200429	68	7/28	200040	753			
7/3	200406	541	7/10	200440	304	7/16	700004	360	7/22	200429	571	7/28	200044	748			
7/3	200408	441	7/10	200452	205	7/16	700008	384	7/22	200438	537	7/28	200402	124			
7/3	200415	600	7/10	200453	110	7/16	700008	245	7/22	200439	104	7/28	200402	100			
7/3	200438	138	7/10	200458	152	7/17	200032	210	7/22	200458	296	7/28	200402	272			
7/3	200469	250	7/10	200458	212	7/17	200061	849	7/22	200458	303	7/28	200420	555			
7/3	200480	300	7/10	200467	210	7/17	200069	704	7/22	200467	121	7/28	200429	550			
7/3	700000	83	7/10	200478	300	7/17	200402	157	7/22	200478	358	7/28	200429	100			
7/3	700000	37	7/11	130110	9032	7/17	200402	204	7/22	700002	1036	7/28	200429	850			
7/3	700003	274	7/11	200038	2640	7/17	200402	214	7/23	200004	2585	7/28	200429	455			
7/7	200019	1530	7/11	200038	3280	7/17	200402	186	7/23	200019	2566	7/28	200478	359			
7/7	200019	147	7/11	200041	363	7/17	200403	76	7/23	200031	279	7/28	700003	30			
7/7	200031	16	7/11	200073	295	7/17	200403	90	7/23	200032	200	7/28	700004	228			
7/7	200031	1016	7/11	200402	124	7/17	200407	251	7/23	200053	746	7/28	700007	230			
7/7	200053	915	7/11	200402	134	7/17	200408	532	7/23	200068	370	7/28	700007	227			
7/7	200402	154	7/11	200402	162	7/17	200425	251	7/23	200402	171	7/28	700008	672			
7/7	200402	178	7/11	200402	160	7/17	200429	1200	7/23	200402	187	7/28	700008	550			
7/7	200416	460	7/11	200429	750	7/17	200439	360	7/23	200402	250	7/29	130110	3010			

Part Sizes

Part Number	Length (inches)	Part Number	Length (inches)
130110	0.25	700002	1.5
200001	4.03	700003	22
200003	3.09	700004	17.28
200004	3.7	700006	2.64
200006	5.01	700007	17.53
200007	2.72	700008	13.41
200008	5.47	700009	3.5
200009	11.41	700011	36
200010	3.34	700013	3.315
200011	3.78	700014	1.99
200014	1.78	700015	3.9
200015	2.34	700016	17.74
200019	1.78	700017	0.903
200020	10.75	700018	1.094
200022	20	700019	5.45
200024	5.09	700020	17.25
200031	9.645	700023	3.83
200032	3.88	700024	5.09
200033	1.915	700025	13.38
200034	2.505	700032	10
200035	9.92	740001	2.26
200036	5.84	740005	5
200037	6.25	740007	13.41
200038	1.46	740022	12
200039	8.34	740023	15
200040	4.69	740030	6.13
200041	5.15		
200043	8.82		
200044	4.4		
200046	3.94		
200048	2.515		
200052	1.56		
200053	7.06		
200055	5.29		
200056	11.41		
200057	4.67		
200060	1.46		
200061	3.06		
200062	3.25		
200068	12.53		
200069	11.62		
200070	12.53		
200071	8.1		
200073	16.53		
200401	18.16		
200402	19.16		
200403	17.34		
200404	19.34		
200405	13.72		
200406	15.94		
200407	17.66		
200408	15.94		
200409	11.28		
200410	15.94		
200411	11.53		
200414	11.42		
200415	9.96		
200416	16.75		
200418	18.43		
200419	14.23		
200420	20.24		
200421	17.66		
200424	15.25		
200425	17.6		
200426	12.75		
200428	14.13		
200429	19.84		

Cutting Production

	01 July -05 July		06-12 July		13-19 July		20-26 July		27-31 July		Montly Totals			
Part Number	Number of Cuts	Size of Cut Piece (ft)	Number of Cuts	Size of Cut Piece (ft)	Number of Cuts	Size of Cut Piece (ft)	Number of Cuts	Size of Cut Piece (ft)	Number of Cuts	Size of Cut Piece (ft)	Number of Cuts	Size of Cut Piece (ft)	Part Number	Cut Size (Inches)
130110	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	130110	0.25
200001	2,903	974.9242	0	0.0000	0	0.0000	1,752	588.3800	0	0.0000	4,655	1,563.3042	200001	4.03
200003	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	200003	3.09
200004	2,509	773.6083	0	0.0000	0	0.0000	2,560	789.3333	0	0.0000	5,069	1,562.9417	200004	3.7
200006	1,811	756.0925	0	0.0000	0	0.0000	2,243	936.4525	0	0.0000	4,054	1,692.5450	200006	5.01
200007	439	99.5067	0	0.0000	0	0.0000	635	143.9333	0	0.0000	1,074	243.4400	200007	2.72
200008	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	200008	5.47
200009	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	200009	11.41
200010	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	200010	3.34
200014	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	200014	1.78
200019	2,814	417.4100	1,677	248.7550	0	0.0000	0	0.0000	0	0.0000	4,491	666.1650	200019	1.78
200031	0	0.0000	1,032	829.4700	0	0.0000	487	391.4263	0	0.0000	1,519	1,220.8963	200031	9.645
200032	794	256.7267	0	0.0000	0	0.0000	0	0.0000	0	0.0000	794	256.7267	200032	3.88
200033	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	200033	1.915
200034	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	200034	2.505
200035	0	0.0000	0	0.0000	0	0.0000	974	805.1733	0	0.0000	974	805.1733	200035	9.92
200036	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	200036	5.84
200037	3,087	1,607.8125	0	0.0000	0	0.0000	1,600	833.3333	0	0.0000	4,687	2,441.1458	200037	6.25
200038	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	200038	1.46
200039	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	200039	8.34
200040	0	0.0000	0	0.0000	0	0.0000	2,162	844.9817	0	0.0000	2,162	844.9817	200040	4.69
200041	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	200041	5.15
200046	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	200046	3.94
200052	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	200052	1.56
200053	0	0.0000	915	538.3250	0	0.0000	0	0.0000	0	0.0000	915	538.3250	200053	7.06
200056	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	200056	11.41
200060	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	200060	1.46
200061	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	200061	3.06
200062	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	200062	3.25
200068	243	253.7325	0	0.0000	0	0.0000	0	0.0000	0	0.0000	243	253.7325	200068	12.53
200069	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	200069	11.62
200070	126	131.5650	0	0.0000	0	0.0000	0	0.0000	0	0.0000	126	131.5650	200070	12.53
200071	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	200071	8.1
200073	171	235.5525	0	0.0000	0	0.0000	0	0.0000	0	0.0000	171	235.5525	200073	16.53
200401	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	200401	18.16
200402	1,960	3,129.4667	332	530.0933	0	0.0000	696	1,111.2800	0	0.0000	2,988	4,770.8400	200402	19.16
200403	0	0.0000	0	0.0000	0	0.0000	179	258.6550	0	0.0000	179	258.6550	200403	17.34
200404	0	0.0000	0	0.0000	0	0.0000	200	322.3333	0	0.0000	200	322.3333	200404	19.34
200405	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	200405	13.72
200406	1,526	2,027.0367	0	0.0000	0	0.0000	0	0.0000	0	0.0000	1,526	2,027.0367	200406	15.94
200407	1,003	1,476.0817	0	0.0000	0	0.0000	1,083	1,593.8150	0	0.0000	2,086	3,069.8967	200407	17.66
200408	1,718	2,282.0767	0	0.0000	0	0.0000	0	0.0000	0	0.0000	1,718	2,282.0767	200408	15.94
200409	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	200409	11.28
200410	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	200410	15.94
200414	0	0.0000	0	0.0000	0	0.0000	407	387.3283	0	0.0000	407	387.3283	200414	11.42
200415	1,350	1,120.5000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	1,350	1,120.5000	200415	9.96
200416	936	1,306.5000	1,425	1,989.0625	0	0.0000	0	0.0000	0	0.0000	2,361	3,295.5625	200416	16.75
200418	400	614.3333	0	0.0000	0	0.0000	0	0.0000	0	0.0000	400	614.3333	200418	18.43
200419	0	0.0000	0	0.0000	0	0.0000	1,000	1,185.8333	0	0.0000	1,000	1,185.8333	200419	14.23
200420	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	200420	20.24
200425	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	200425	17.6
200426	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	200426	12.75
200428	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	200428	14.13
200429	2,318	3,832.4267	876	1,448.3200	0	0.0000	1,029	1,701.2800	0	0.0000	4,223	6,982.0267	200429	19.84
200438	1,155	1,834.5250	0	0.0000	0	0.0000	0	0.0000	0	0.0000	1,155	1,834.5250	200438	19.06
200439	448	529.7600	0	0.0000	0	0.0000	0	0.0000	0	0.0000	448	529.7600	200439	14.19
200440	400	442.6667	0	0.0000	0	0.0000	0	0.0000	0	0.0000	400	442.6667	200440	13.28
200443	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	200443	11
200444	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	200444	21.5
200449	260	394.1167	0	0.0000	0	0.0000	0	0.0000	0	0.0000	260	394.1167	200449	18.19
200452	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	200452	13.81
200453	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	200453	15.37
200455	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	200455	15.71
200458	632	495.5933	0	0.0000	0	0.0000	0	0.0000	0	0.0000	632	495.5933	200458	9.41
200462	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	200462	5.86
200467	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	200467	10.31
200468	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	200468	16
200469	250	346.0417	0	0.0000	0	0.0000	0	0.0000	0	0.0000	250	346.0417	200469	16.61
200478	0	0.0000	0	0.0000	0	0.0000	608	935.8133	0	0.0000	608	935.8133	200478	18.47
200479	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	200479	12.2
200480	300	183.5000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	300	183.5000	200480	7.34
200482	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	200482	12.75
200533	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	200533	10.28
700000	620	161.2000	0	0.0000	0	0.0000	3,426	890.7600	0	0.0000	4,046	1,051.9600	700000	3.12
700001	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	700001	4.815
700002	1,626	652.4325	0	0.0000	0	0.0000	0	0.0000	0	0.0000	1,626	652.4325	700002	4.815
700003	274	109.9425	0	0.0000	0	0.0000	0	0.0000	0	0.0000	274	109.9425	700003	4.815
700004	232	93.0900	0	0.0000	0	0.0000	0	0.0000	0	0.0000	232	93.0900	700004	4.815
700006	1,443	579.0038	0	0.0000	0	0.0000	0	0.0000	0	0.0000	1,443	579.0038	700006	4.815
700007	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	700007	4.815
700008	0	0.0000	0	0.0000	0	0.0000	310	124.3875	0	0.0000	310	124.3875	700008	4.815
700009	1,415	567.7688	0	0.0000	0	0.0000	0	0.0000	0	0.0000	1,415	567.7688	700009	4.815
700011	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	700011	4.815
700013	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	700013	4.815
700023	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	700023	4.815
740001	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	740001	4.815
740005	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	740005	4.815
740007	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	740007	4.815
740022	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	740022	4.815
740023	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	0	0.0000	740023	4.815
Totals:	35,163	27,684.9933	6,257	5,584.0258	0	0.0000	21,351	13,844.4996	0	0.0000	62,771	47,113.5188		

APPENDIX C3

June 2003 - Perforated Steel Tubing

Raw Material	Beginning Inventory	Receipts					Ending Inventory	Material Used
		2-Jun	9-Jun	16-Jun	23-Jun	Total Receipts		
120110	3,280		1,740			1,740	1,920	3,100
120111	7,360	2,480	2,480	2,480	2,480	9,920	8,880	8,400
120112	3,320		2,480			2,480	3,066	2,734
120113	30,880	6,960	6,960	6,960	6,960	27,840	37,866	20,854
120115	22,180	2,320	2,320	4,640	4,640	13,920	19,031	17,069
120116	7,740		2,320		2,320	4,640	9,420	2,960
120117	10,240	2,320			2,320	4,640	8,345	6,535
120120	70,460		9,280	9,280	9,280	27,840	61,438	36,862
120124	4,124				2,440	2,440	2,440	4,124
120125	2,480		2,300			2,300	2,380	2,400
120131	6,620	2,480	2,480	2,480		7,440	9,358	4,702
120149	4,780	2,700			2,200	4,900	3,834	5,846
120150	4,060		2,700			2,700	4,745	2,015
120151	2,700					0	2,500	200
120153	820					0	600	220
120154	17,040					0	16,780	260
120157	18,000					0	17,040	960
120214	6,684		2,700		2,700	5,400	7,080	5,004
120215	7,520		2,100			2,100	8,400	1,220
120216	4,240		2,980			2,980	5,480	1,740
120223	8,640					0	8,620	20
120161	3,820					0	2,764	1,056
120219	3,540					0	2,580	960

Total Material Used:	129,242
Amount Cut Per Production Logs:	96,070
Manufacturing Drop (Waste):	33,172
Manufacturing Drop (Waste) Percentage:	25.67%

June 2003 - Screen Steel Tubing

Raw Material	Beginning Inventory	Receipts					Ending Inventory	Material Used
		2-Jun	9-Jun	16-Jun	23-Jun	Total Receipts		
120128	37,869	9,500	11,400	11,400	11,400	43,700	40,573	40,996
120129	2,677	2,040	1,020	1,020	2,040	6,120	3,096	5,700
120158	2,921					0	1,800	1,121
120162	15,600					0	15,600	0
120163	2,337	5,451	7,588	5,691	7,588	26,318	2,106	26,549

Total Material Used:	74,366
Amount Cut Per Production Logs:	62,078
Manufacturing Drop (Waste):	12,288
Manufacturing Drop (Waste) Percentage:	16.52%

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APPENDIX C4

July 2003 - Perforated Steel Tubing

Raw Material	Beginning Inventory	Receipts							Ending Inventory	Material Used
		1-Jul	7-Jul	14-Jul	21-Jul	28-Jul	31-Jul	Total Receipts		
120110	1,920							0	1,500	420
120111	8,880		2,480	2,480		2,480		7,440	12,110	4,210
120112	3,066		2,480					2,480	3,200	2,346
120113	37,866	5,580	6,960	6,960	6,960		1,272	27,732	27,678	37,920
120115	19,031	2,320	4,640	2,320	4,640	2,320		16,240	17,561	17,710
120116	9,420		2,320		2,320		355	4,995	9,340	5,075
120117	8,345		2,320	2,320	2,320	2,320	475	9,755	11,320	6,780
120120	61,438		9,280	9,280	9,280		2,459	30,299	73,471	18,266
120124	2,440	2,180			2,300			4,480	931	5,990
120125	2,380						388	388	2,300	468
120131	9,358	2,480	2,480			2,340	260	7,560	13,369	3,549
120149	3,834	2,700					322	3,022	2,115	4,741
120150	4,745	2,700			2,700		621	6,021	8,600	2,166
120151	2,500							0	2,500	0
120152	10,900							0	10,360	540
120153	600							0	300	300
120157	17,040							0	16,000	1,040
120214	7,080		2,700		2,700		425	5,825	7,400	5,505
120215	8,400	2,700			2,700			5,400	11,620	2,180
120216	5,480	2,700			2,700		841	6,241	6,900	4,821
120223	8,620							0	7,100	1,520
120161	2,764			3,780				3,780	5,080	1,464
120219	2,580							0	2,520	60

Total Material Used:	127,070
Amount Cut Per Production Logs:	106,193
Manufacturing Drop (Waste):	20,877
Manufacturing Drop (Waste) Percentage:	16.43%

July 2003 - Screen Steel Tubing

Raw Material	Beginning Inventory	Receipts							Ending Inventory	Material Used
		1-Jul	7-Jul	14-Jul	21-Jul	28-Jul	31-Jul	Total Receipts		
120128	40573	9,500	11,400	9,500	9,500		241	40,141	43399	37,315
120129	3096	1,020	2,040	1,020	1,020	2,040		7,140	4680	5,556
120158	1800							0	600	1,200
120162	15600						21,245	21,245	31440	5,405
120163	2106	3,794	7,588	5,691	7,588	9,485		34,146	9070	27,182

Total Material Used:	76,658
Amount Cut Per Production Logs:	59,020
Manufacturing Drop (Waste):	17,638
Manufacturing Drop (Waste) Percentage:	23.01%

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APPENDIX C5

Perforated Raw Material Inventory

Part Number	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL
120110	7,440	5,020	5,560	4,960	2,430	5,640	4,870	4,100	2,580	3,200	3,280	1,920	1,500
120111	3,914	714	334	677	2,778	2,480	2,348	0	3,120	3,040	7,360	8,880	12,110
120112	9,920	7,440	5,320	4,960	2,980	4,760	3,120	2,820	240	2,180	3,320	3,066	3,200
120113	9,384	15,546	19,122	15,554	13,048	28,040	25,332	22,140	24,992	25,439	30,880	37,866	27,678
120114	5,540	5,440	5,600	5,100	4,970	5,540	5,540	4,314	4,000	4,000	4,420	4,440	4,460
120115	21,828	12,071	7,920	5,715	3,232	10,820	11,370	10,352	10,161	13,383	22,180	19,031	17,561
120116	18,171	8,561	9,400	5,718	4,336	5,900	4,749	3,526	5,794	9,280	7,740	9,420	9,340
120117	13,920	5,106	4,640	1,799	5,260	8,420	7,078	9,000	10,328	11,320	10,240	8,345	11,320
120120	31,590	43,635	57,391	37,825	22,872	36,140	38,727	59,653	81,532	59,624	70,460	61,438	73,471
120124	5,000	6,109	2,440	1,865	2,523	2,920	3,179	4,141	2,300	3,343	4,124	2,440	931
120125	5,700	5,100	3,800	2,535	1,477	1,820	4,200	5,640	3,760	1,400	2,480	2,380	2,300
120131	2,899	1,000	920	640	0	3,380	3,082	3,700	2,393	1,960	6,620	9,358	13,369
120149	9,955	6,220	8,630	10,235	8,151	5,840	2,035	1,508	0	4,820	4,780	3,834	2,115
120150	1,840	1,840	1,840	1,657	2,000	2,480	2,480	2,640	2,520	2,500	2,700	2,500	2,500
120151	11,020	11,260	11,200	10,880	10,900	10,960	10,960	10,980	10,920	10,880	10,440	10,900	10,360
120152	2,320	2,000	2,000	2,000	1,823	1,840	1,840	1,680	1,203	1,100	820	600	300
120153	20,000	16,000	21,840	20,000	19,260	16,000	20,000	19,680	17,632	17,800	17,040	16,780	16,800
120154	25,625	24,199	24,400	23,785	22,760	22,720	21,863	21,600	20,000	18,720	18,000	17,040	16,000
120157	7,020	6,951	16	3,661	5,925	10,260	7,524	8,465	2,641	5,490	6,684	7,080	7,400
120214	12,580	5,716	3,316	1,853	2,917	4,960	3,947	4,077	6,500	7,680	7,520	8,400	11,620
120215	10,920	6,845	4,460	178	2,713	6,520	6,474	5,240	1,533	4,200	4,240	5,480	6,900
120216	0	6,960	6,960	9,040	8,960	8,060	7,935	7,700	6,960	8,400	8,640	8,620	7,100
120223	2,700	2,700	974	0	3,049	2,420	0	2,109	4,436	3,920	4,060	4,745	8,600
120161	5,680	5,420	4,408	3,359	3,640	3,080	2,335	1,400	920	0	3,820	2,764	5,080
120219	1,840	3,540	3,020	4,520	5,480	5,340	5,340	4,900	3,980	3,380	3,540	2,580	2,520

Part Number	Avg Monthly Inventory	Price Per Foot	Avg Monthly Inventory Value
120110	4,038	$0.73	$2,948
120111	3,673	$0.32	$1,176
120112	4,102	$0.73	$2,994
120113	22,694	$0.78	$17,701
120114	4,874	$0.76	$3,704
120115	12,740	$0.76	$9,683
120116	7,841	$0.77	$6,038
120117	8,214	$0.87	$7,146
120120	51,874	$0.75	$38,905
120124	3,178	$0.95	$3,019
120125	3,276	$0.99	$3,244
120131	3,794	$0.73	$2,770
120149	5,240	$0.86	$4,507
120150	2,269	$0.99	$2,246
120151	10,897	$1.12	$12,205
120152	1,502	$0.43	$646
120153	18,372	$0.53	$9,737
120154	21,286	$1.50	$31,928
120157	6,086	$0.84	$5,112
120214	6,237	$0.84	$5,239
120215	5,054	$0.82	$4,144
120216	7,333	$0.83	$6,087
120223	3,055	$0.86	$2,627
120161	3,224	$1.12	$3,610
120219	3,845	$1.15	$4,421

Average Monthly Inventory (ft): 224,699
Average Monthly Value of Inventory: $191,838
Average Price Per Foot of Monthly Inventory: $0.85

Screen Raw Material Inventory

Part Number	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL
120128	25,344	33,606	36,100	35,763	28,188	43,340	33,085	30,443	63,422	33,390	37,869	40,573	43,399
120129	8,232	3,226	1,369	1	2,355	4,760	2,703	3,302	1,560	2,406	2,677	3,096	4,680
120158	9,480	8,920	7,755	7,502	6,840	6,860	6,149	6,240	5,695	4,180	2,921	1,800	600
120162	0	14,900	14,700	14,660	14,605	14,400	15,218	15,600	15,600	15,600	15,600	15,600	31,440
120163	0	0	0	0	0	0	0	4,413	17,100	993	2,337	2,106	9,070

Part Number	Avg Monthly Inventory	Price Per Foot	Avg Monthly Inventory Value
120128	37,271	$1.12	$41,743
120129	3,105	$1.23	$3,819
120158	5,765	$1.19	$6,860
120162	15,225	$1.09	$16,595
120163	2,771	$1.07	$2,965

Average Monthly Inventory (ft): 64,136
Average Monthly Value of Inventory: $71,982
Average Price Per Foot of Monthly Inventory: $1.12

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APPENDIX C6

Man-Hours Input Data

Average Employee Hourly Pay (Salinas):	$16.14
Average Employee Hourly Pay (Lincoln):	$14.33
Number of Personnel Required at Salinas:	133
Weekly Man Hours Programmed for Shear cutter:	40
Weekly Man Hours Programmed for Cold Saw:	80
Weekly Man Hours Programmed for Roll Cutter:	80
Weekly Man Hours Programmed for KMT saw:	50
Weekly Man Hours Programmed for Modern cutter:	80
Weekly Man Hours Programmed for New Perf-cutting Modern cutter:	0
Total Weekly Man Hours Programmed for Cutting :	330
Annual Man Hours Programmed for Cutting (based on 50 weeks):	16504
Total Annual Man Hours Programmed for Production:	201,762
Total Annual Man Hours Programmed for Production (less cutting operation):	185,262

Cost Output

Manpower Cost for Cutting:	$ 266,380
Transportation Costs:	$ 106,250
Total Costs:	$ 372,630

Machine Inputs

	Cutting Rate (hrs/piece)	Theoretical Cutting Rate (Pieces per hr)	Average Actual Weekly Production (Pieces)	Average Cutting Rate (Pieces per hr)	Weekly Man-Hours Required to Obtain Capacity	Realized Capacity
Shear Cutter Rate:	0.0050	200	4,440	111	40	55.46%
Cold Saw Cutting Rate:	0.0050	200	8,000	100	80	50.00%
Roll Cutter Rate:	0.0050	200	11,200	140	80	69.96%
KMT (Screen) Saw Rate:	0.0083	120	3,955	79	50	65.89%
Modern (existing) Cutter Rate:	0.0010	1000	40,026	500	80	50.03%
Modern (new) Cutter Rate:	0.0044	227	n/a	n/a	0	n/a
				Total:	330	

Transportation Inputs

Miles Between Valmont (CNT) and GMIS:	1700	
Cost per mile:	$1.25	1 Average Trips per week
Cost Per Trip:	$2,125.00	50 Average Trips per year
Annual Tranportation Cost:	$106,250.00	
Miles Between Valmont (CNT) and GMIL:	19	
Cost per mile:	$1.25	0 Average Trips per week
Cost Per Trip:	$23.75	0 Average Trips per year
Annual Tranportation Cost:	$0.00	
Miles Between GMIL and GMIS:	1700	
Cost per mile:	$1.25	0 Average Trips per week
Cost Per Trip:	$2,125.00	0 Average Trips per year
Annual Tranportation Cost:	$0.00	
Total Annual Transportation Costs:	$106,250.00	

Drop/Scrap Data

Range (Min):	16.43%
Range (Max):	25.39%
Average:	20.91%

New Capital

Base Machine:	$147,800
Cut-off Tool Holder & ID Chamfer Attachment:	$6,090
Automatic Bar Feeder:	$41,100
Extra Hardened Steel Collect:	$600
Extra Guide Tube:	$495
Number of Stock Sizes:	3
Total Capital Investment:	$196,085

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APPENDIX C7

Man-Hours Input Data

Average Employee Hourly Pay (Salinas):	$16.14
Average Employee Hourly Pay (Lincoln):	$14.33
Weekly Man Hours Programmed for Shear cutter:	40
Weekly Man Hours Programmed for Cold Saw:	80
Weekly Man Hours Programmed for Roll Cutter:	80
Weekly Man Hours Programmed for KMT saw:	50
Weekly Man Hours Programmed for Modern cutter:	80
Weekly Man Hours Programmed for New Perf-cutting Modern cutter:	0
Total Weekly Man Hours Programmed for Perf/Screen Cutting :	250
Annual Man Hours Programmed for Perf/Screen Cutting (based on 50 weeks):	12504
Total Annual Man Hours Programmed for Production:	201,762
Total Annual Man Hours Programmed for Production (less cutting operation):	185,262

Cost Output

Manpower Cost for Cutting:	$243,746
Total Transportation Costs:	$85,221
Total Costs to Operate Cutting Operation:	$328,967

Machine Inputs

	Cutting Rate (hrs/piece)	Theoretical Cutting Rate (Pieces per hr)	Average Weekly Production	Average Realized Cutting Rate (Pieces per hr)	Realized Capacity	Weekly Man-Hours Required to Obtain Capacity Level
Shear Cutter Rate:	0.0050	200	4,440	111	55.46%	40
Cold Saw Cutting Rate:	0.0050	200	8,000	100	50.00%	80
Roll Cutter Rate:	0.0050	200	11,200	140	69.96%	80
KMT (Screen) Saw Rate:	0.0083	120	3,955	79	65.89%	50
Modern (existing) Cutter Rate:	0.0010	1000	40,026	500	50.03%	80
Modern (new) Cutter Rate:	0.0044	227	n/a	n/a	n/a	0
					Total:	330

Transportation Costs

Miles Between Valmont (CNT) and GMIS:	1700	
Cost per mile:	$1.25	0 Average Trips per week
Cost Per Trip:	$2,125.00	0 Average Trips per year
Annual Tranportation Cost:	$0.00	
Miles Between Valmont (CNT) and GMIL:	19	
Cost per mile:	$1.25	1 Average Trips per week
Cost Per Trip:	$23.75	50 Average Trips per year
Annual Tranportation Cost:	$1,187.50	
Miles Between GMIL and GMIS:	1700	
Cost per mile:	$1.25	0.7909 Average Trips per week
Cost Per Trip:	$2,125.00	39.545 Average Trips per year
Annual Tranportation Cost:	$84,033.13	
Total Annual Transportation Costs:	$85,220.63	

Drop/Scrap Data

Range:	16.43%	25.39%
Average:	20.91%	

New Capital

Cost of New Machine (Modern):

Base Machine:	$147,800
Cut-off Tool Holder & ID Chamfer Attachment:	$6,090
Automatic Bar Feeder:	$41,100
Extra Hardened Steel Collect:	$600
Extra Guide Tube:	$495
Number of Stock Sizes:	3
Total Capital Investment:	$196,085

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APPENDIX C8

Man-Hours Input Data	
Average Employee Hourly Pay (Salinas):	$16.14
Average Employee Hourly Pay (Lincoln):	$14.33
Number of Personnel Required at Salinas:	133
Weekly Man Hours Programmed for Shear cutter:	0
Weekly Man Hours Programmed for Cold Saw:	0
Weekly Man Hours Programmed for Roll Cutter:	80
Weekly Man Hours Programmed for KMT saw:	50
Weekly Man Hours Programmed for Modern cutter:	80
Weekly Man Hours Programmed for New Perf-cutting Modern cutter:	80
Total Weekly Man Hours Programmed for Cutting :	290
Annual Man Hours Programmed for Cutting (based on 50 weeks):	14503
Total Annual Man Hours Programmed for Production:	201,762
Baseline Annual Man-hours Programmed for Cutting:	16,500
Total Annual Man Hours Programmed for Production (less cutting operation):	185,262

Cost Output	
Manpower Cost for Cutting:	$234,072
Transportation Costs:	$106,250
Total Costs:	$340,322

Machine Inputs

	Cutting Rate (hrs/piece)	Theoretical Cutting Rate (Pieces per hr)	Average Weekly Production	Average Cutting Rate (Pieces per hr)	Achieved Capacity	Weekly Man-Hours Required to Obtain Capacity Level
Shear Cutter Rate:	0.0050	200	4,440	n/a	n/a	0
Cold Saw Cutting Rate:	0.0050	200	8,000	n/a	n/a	0
Roll Cutter Rate:	0.0050	200	11,200	140	70.0%	80
KMT (Screen) Saw Rate:	0.0083	120	3,955	79	65.9%	50
Modern (existing) Cutter Rate:	0.0010	1000	40,026	500	50.0%	80
Modern (new) Cutter Rate:	0.0044	225	12,440	156	69%	80
					Total:	290

*New Modern cutter replaces the Cold Saw and the Shear Cutter
** must be able to operate new Modern Cutter >69% utilization to replace more than one machine

Transportation Costs

Miles Between GMIL and GMIS:	1700		
Cost per mile:	$ 1.25	0	Average Trips per week
Cost Per Trip:	$ 2,125.00	0	Average Trips per year
Annual Tranportation Cost:	$ -		
Miles Between Valmont (CNT) and GMIS:	1700		
Cost per mile:	$ 1.25	1	Average Trips per week
Cost Per Trip:	$ 2,125.00	50	Average Trips per year
Annual Tranportation Cost:	$106,250.00		
Miles Between Valmont (CNT) and GMIL:	19		
Cost per mile:	$ 1.25	0	Average Trips per week
Cost Per Trip:	$ 23.75	0	Average Trips per year
Annual Tranportation Cost:	$ -		
Total Annual Transportation Costs:	$106,250.00		

Drop/Scrap	
Range (Min):	16.43%
Range (Max):	25.39%
Average:	20.91%

New Capital	
Base Machine:	$147,800
Cut-off Tool Holder & ID Chamfer Attachment:	$6,090
Automatic Bar Feeder:	$41,100
Extra Hardened Steel Collect:	$600
Extra Guide Tube:	$495
Number of Stock Sizes:	3
Total Capital Investment:	$196,085

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APPENDIX C9

Man-Hours Input Data	
Average Employee Hourly Pay (Salinas):	$16.14
Average Employee Hourly Pay (Lincoln):	$14.33
Weekly Man Hours Programmed for Shear cutter:	0
Weekly Man Hours Programmed for Cold Saw:	0
Weekly Man Hours Programmed for Roll Cutter:	80
Weekly Man Hours Programmed for KMT saw:	50
Weekly Man Hours Programmed for Modern cutter:	80
Weekly Man Hours Programmed for New Perf-cutting Modern cutter:	80
Total Weekly Man Hours Programmed for Cutting :	210
Annual Man Hours Programmed for Cutting (based on 50 weeks):	10503
Total Annual Man Hours Programmed for Production:	201,762
Baseline Annual Man-hours Programmed for Cutting:	16,500
Total Annual Man Hours Programmed for Production (less cutting operation):	185,262

Cost Output	
Manpower Cost for Cutting:	$215,061
Transportation Costs:	$85,221
Total Costs:	$300,282

Machine Inputs

	Cutting Rate (hrs/piece)	Theoretical Cutting Rate (Pieces per hr)	Average Weekly Production	Actual Cutting Rate (Pieces per hr)	Achieved Capacity	Weekly Man-Hours Required to Obtain Capacity Level
Shear Cutter Rate:	0.0050	200	4,440	n/a	n/a	0
Cold Saw Cutting Rate:	0.0050	200	8,000	n/a	n/a	0
Roll Cutter Rate:	0.0050	200	11,200	140	69.96%	80
KMT (Screen) Saw Rate:	0.0083	120	3,955	79	65.89%	50
Modern (existing) Cutter Rate:	0.0010	1000	40,026	500	50.03%	80
Modern (new) Cutter Rate:	0.0044	225	12,440	156	69.11%	80
					Total:	290

*New Modern cutter replaces the Cold Saw and the Shear Cutter
** must be able to operate new Modern Cutter at >70% to replace more than one machine

Transportation Costs

Miles Between GMIL and GMIS:	1700	
Cost per mile:	$ 1.25	0.7909 Average Trips per week
Cost Per Trip:	$ 2,125.00	39.545 Average Trips per year
Annual Tranportation Cost:	$ 84,033.13	
Miles Between Valmont (CNT) and GMIS:	1700	
Cost per mile:	$ 1.25	0 Average Trips per week
Cost Per Trip:	$ 2,125.00	0 Average Trips per year
Annual Tranportation Cost:	$ -	
Miles Between Valmont (CNT) and GMIL:	19	
Cost per mile:	$ 1.25	1 Average Trips per week
Cost Per Trip:	$ 23.75	50 Average Trips per year
Annual Tranportation Cost:	$ 1,187.50	
Total Annual Transportation Costs:	$ 85,220.63	

Drop/Scrap Data		
Range:	16.43%	25.39%
Average:	20.91%	

New Capital

Cost of New Machine (Modern):	
Base Machine:	$147,800
Cut-off Tool Holder & ID Chamfer Attachment:	$6,090
Automatic Bar Feeder:	$41,100
Extra Hardened Steel Collect:	$600
Extra Guide Tube:	$495
Number of Stock Sizes:	3
Total Capital Investment:	$196,085

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APPENDIX C10

Man-Hours Input Data	
Average Employee Hourly Pay (Salinas):	$16.14
Average Employee Hourly Pay (Lincoln):	$14.33
Number of Personnel Required at Salinas:	133
Weekly Man Hours Programmed for Shear cutter:	32
Weekly Man Hours Programmed for Cold Saw:	57
Weekly Man Hours Programmed for Roll Cutter:	80
Weekly Man Hours Programmed for KMT saw:	47
Weekly Man Hours Programmed for Modern cutter:	57
Weekly Man Hours Programmed for New Perf-cutting Modern cutter:	0
Total Weekly Man Hours Programmed for Cutting :	273
Annual Man Hours Programmed for Cutting (based on 50 weeks):	13656
Total Annual Man Hours Programmed for Production:	201,762
Total Annual Man Hours Programmed for Production (less cutting operation):	185,262

Cost Output	
Manpower Cost for Cutting:	$220,409
Transportation Costs:	$106,250
Total Costs:	$326,659

Machine Inputs

	Cutting Rate (hrs/piece)	Theoretical Cutting Rate (Pieces per hr)	Average Actual Weekly Production (Pieces)	Average Cutting Rate (Pieces per hr)	Weekly Man-Hours Required to Obtain Capacity Level	Realized Capacity
Shear Cutter Rate:	0.0050	200	4,440	140	32	70.0%
Cold Saw Cutting Rate:	0.0050	200	8,000	140	57	70.0%
Roll Cutter Rate:	0.0050	200	11,200	140	80	70.0%
KMT (Screen) Saw Rate:	0.0083	120	3,955	84	47	70.0%
Modern (existing) Cutter Rate:	0.0010	1000	40,026	700	57	70.0%
Modern (new) Cutter Rate:	0.0044	227	n/a	n/a	0	n/a
				Totals:	273	

Transportation Costs

Miles Between Valmont (CNT) and GMIS:	1700	
Cost per mile:	$1.25	1 Average Trips per week
Cost Per Trip:	$2,125.00	50 Average Trips per year
Annual Tranportation Cost:	$106,250.00	
Miles Between Valmont (CNT) and GMIL:	19	
Cost per mile:	$1.25	0 Average Trips per week
Cost Per Trip:	$23.75	0 Average Trips per year
Annual Tranportation Cost:	$0.00	
Miles Between GMIL and GMIS:	1700	
Cost per mile:	$1.25	0 Average Trips per week
Cost Per Trip:	$2,125.00	0 Average Trips per year
Annual Tranportation Cost:	$0.00	
Total Annual Transportation Costs:	$106,250.00	

Drop/Scrap Data	
Range (Min):	16.43%
Range (Max):	25.39%
Average:	20.91%

New Capital	
Base Machine:	$147,800
Cut-off Tool Holder & ID Chamfer Attachment:	$6,090
Automatic Bar Feeder:	$41,100
Extra Hardened Steel Collect:	$600
Extra Guide Tube:	$495
Number of Stock Sizes:	3
Total Capital Investment:	$196,085

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APPENDIX C11

Man-Hours Input Data	
Average Employee Hourly Pay (Salinas):	$16.14
Average Employee Hourly Pay (Lincoln):	$14.33
Number of Personnel Required at Salinas:	133
Weekly Man Hours Programmed for Shear cutter:	32
Weekly Man Hours Programmed for Cold Saw:	57
Weekly Man Hours Programmed for Roll Cutter:	80
Weekly Man Hours Programmed for KMT saw:	47
Weekly Man Hours Programmed for Modern cutter:	57
Weekly Man Hours Programmed for New Perf-cutting Modern cutter:	n/a
Total Weekly Man Hours Programmed for Cutting :	216
Annual Man Hours Programmed for Cutting (based on 50 weeks):	10797
Total Annual Man Hours Programmed for Production:	201,762
Total Annual Man Hours Programmed for Production (less cutting operation):	185,262

Cost Output	
Manpower Cost for Cutting (Salinas):	$200,866
Total Transportation Costs:	$85,221
Total Costs to Operate in Salinas:	$286,087

Machine Inputs

	Cutting Rate (hrs/piece)	Theoretical Cutting Rate (Pieces per hr)	Average Actual Weekly Production (Pieces)	Average Cutting Rate (Pieces per hr)	Weekly Man-Hours Required to Obtain Capacity Level	Realized Capacity
Shear Cutter Rate:	0.0050	200	4,440	140	32	70.0%
Cold Saw Cutting Rate:	0.0050	200	8,000	140	57	70.0%
Roll Cutter Rate:	0.0050	200	11,200	140	80	70.0%
KMT (Screen) Saw Rate:	0.0083	120	3,955	84	47	70.0%
Modern (existing) Cutter Rate:	0.0010	1000	40,026	700	57	70.0%
Modern (new) Cutter Rate:	0.0044	227	n/a	n/a	n/a	n/a
				Totals:	273	

Transportation Costs

Miles Between Valmont (CNT) and GMIS:	1700	
Cost per mile:	$1.25	0 Average Trips per week
Cost Per Trip:	$2,125.00	0 Average Trips per year
Annual Tranportation Cost:	$0.00	
Miles Between Valmont (CNT) and GMIL:	19	
Cost per mile:	$1.25	1 Average Trips per week
Cost Per Trip:	$23.75	50 Average Trips per year
Annual Tranportation Cost:	$1,187.50	
Miles Between GMIL and GMIS:	1700	
Cost per mile:	$1.25	79.09% Average Trips per week
Cost Per Trip:	$2,125.00	39.545 Average Trips per year
Annual Tranportation Cost:	$84,033.13	
Total Annual Transportation Costs:	$85,220.63	

Drop/Scrap Data		
Range:	16.43%	25.39%
Average:	20.91%	

New Capital

Cost of New Machine (Modern):	
Base Machine:	$147,800
Cut-off Tool Holder & ID Chamfer Attachment:	$6,090
Automatic Bar Feeder:	$41,100
Extra Hardened Steel Collect:	$600
Extra Guide Tube:	$495
Number of Stock Sizes:	3
Total Capital Investment:	$196,085

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APPENDIX C12

Man-Hours Input Data

Average Employee Hourly Pay (Salinas):	$16.14					
Average Employee Hourly Pay (Lincoln):	$14.33					
Number of Personnel Required at Salinas:	133					
	Current Utilization		New Capital		70% Utilization	
	Weekly	Annual	Weekly	Annual	Weekly	Annual
Man Hours Programmed for Shear cutter:	40	2000	0	0	32	1600
Man Hours Programmed for Cold Saw:	80	4000	0	0	57	2850
Man Hours Programmed for Roll Cutter:	80	4000	80	4000	80	4000
Man Hours Programmed for KMT saw:	50	2500	50	2500	47	2350
Man Hours Programmed for Modern cutter:	80	4000	80	4000	57	2850
Man Hours Programmed for New Perf-cutting Modern cutter:	0	0	80	4000	0	0
Weeks Programmed for Cutting Each Year:	50					
Annual Man Hours Programmed for Cutting (based on 50 weeks):	2500					
Total Annual Man Hours Programmed for Production:	201,762					
Total Annual Man Hours Programmed for Production (less cutting operation):	185,262					

Machine Inputs

	Cutting Rate (hrs/piece)	Theoretical Cutting Rate (Pieces per	Average Actual Weekly Production	Average Cutting Rate (Pieces per	Weekly Man-Hours Required to Obtain	Realized Capacity
Shear Cutter Rate:	0.0050	200	4,440	111	40	55.46%
Cold Saw Cutting Rate:	0.0050	200	8,000	100	80	50.00%
Roll Cutter Rate:	0.0050	200	11,200	140	80	69.96%
KMT (Screen) Saw Rate:	0.0083	120	3,955	79	50	65.89%
Modern (existing) Cutter Rate:	0.0010	1000	40,026	500	80	50.03%
Modern (new) Cutter Rate:	0.0044	227	n/a	n/a	0	n/a
				Total:	330	

Transportation Inputs

		If at Salinas		If at Lincoln		
les Between Valmont (CNT) and GMIS:	1700				1700	Miles Between Valmont (CNT) and GMIS:
Cost per mile:	$1.25	1	Average Trips per week	0	$1.25	Cost per mile:
Cost Per Trip:	$2,125.00	50	Average Trips per year	0	$2,125.00	Cost Per Trip:
Annual Tranportation Cost:	$106,250.00				$0.00	Annual Tranportation Cost:
iles Between Valmont (CNT) and GMIL:	19				19	Miles Between Valmont (CNT) and GMIL:
Cost per mile:	$1.25	0	Average Trips per week	1	$1.25	Cost per mile:
Cost Per Trip:	$23.75	0	Average Trips per year	50	$23.75	Cost Per Trip:
Annual Tranportation Cost:	$0.00				$1,187.50	Annual Tranportation Cost:
Miles Between GMIL and GMIS:	1700				1700	Miles Between GMIL and GMIS:
Cost per mile:	$1.25	0	Average Trips per week	0.7909	$1.25	Cost per mile:
Cost Per Trip:	$2,125.00	0	Average Trips per year	39.5450	$2,125.00	Cost Per Trip:
Annual Tranportation Cost:	$0.00				$84,033.13	Annual Tranportation Cost:
Total Annual Transportation Costs:	$106,250.00				$85,220.63	Total Annual Transportation Costs:

Drop/Scrap Data

Range (Min):	16%
Range (Max):	26%
Average:	21%

New Capital

Base Machine:	$147,800
Cut-off Tool Holder & ID Chamfer Attachment:	$6,090
Automatic Bar Feeder:	$41,100
Extra Hardened Steel Collect:	$600
Extra Guide Tube:	$495
Number of Stock Sizes:	3
Total Capital Investment:	$196,085

Savings Output

	Salinas (Baseline)	Lincoln (No Capital)	Salinas New Capital	Lincoln New Capital	Salinas (at 70%)	Lincoln (at 70%)
Manpower Cost for Cutting:	$ 266,310	$ 243,685	$ 234,030	$ 215,025	$ 220,311	$ 200,763
Total Transportation Costs:	$ 106,250	$ 85,221	$ 106,250	$ 85,221	$ 106,250	$ 85,221
Total Costs:	$ 372,560	$ 328,906	$ 340,280	$ 300,246	$ 326,561	$ 285,984
Total Cost Savings:		$ 43,654	$ 32,280	$ 72,314	$ 45,999	$ 86,576

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